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Regional

ENVIRONMENTAL
ANALYSIS
RECORD

POTASH LEASING
in
SOUTHEASTERN NEW MEXICO

U. S. Department of the Interior
Bureau of Land Management
New Mexico State Office

OCTOBER, 1975

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PRELIMINARY REGIONAL POTASH ENVIRONMENTAL ANALYSIS RECORD

Introduction

The Preliminary Regional Environmental Analysis Record for Potash Leasing has been written in a manner to try and make it understandable to the public. The interdisciplinary approach to the analysis of the mining and refining processes and environmental impacts is quite complicated. This complexity necessitates a certain amount of repetition to facilitate understanding by the lay reader or the reader who may be interested in only one or two facets of the environment.

It is the policy of the Department of the Interior to encourage the development of the mineral resources under its jurisdiction where mining is authorized. In permitting minerals development, the Department requires that adequate measures be taken to protect the natural environment and to minimize hazards to public health and safety.

Specifically, the Secretary of the Interior, acting through the Bureau of Land Management (BLM), and the U. S. Geological Survey (USGS), has authority under the 1920 Minerals Leasing Act (PL 146-66), as amended by the Potash Leasing Act of 1927, to lease potash reserves on Federal lands.

The following Acts and Orders all elaborate responsibilities of the Secretary in exercising his authority under the Minerals Leasing Act:

1) Antiquities Act of 1906 (PL 54-204)-Antiquities Protection.

2) Historic Sites Act of 1935 (PL 74-292)-Historical Sites Protection.

3) Reservoir Salvage Act of 1960 (Pl 86-523) - Antiquities Protection.

4) National Historic Preservation Act of October 15, 1966 (PL 89-665) - Protection of National Historic Register Sites.

5) National Environmental Policy Act of 1969 (PL 91-190)-Environmental Protection.

6) Executive Order 11514 of March 5, 1970-Environmental Protection.

7) Executive Order 11593 of May 13, 1971-Protection of National Historic Register Sites.

8) Historical and Archeological Data Preservation Act of 1971 (PL 93-291)-Antiquities and Historic Sites Protection.

9) Endangered Species Act of 1973 (PL 93-205)-Wildlife Protection.

10) Secretarial Order 2948 of October 6, 1972-Mineral Leasing Responsibility.

The National Environmental Policy Act (NEPA) of 1969 directs Federal agencies to use a systematic, interdisciplinary approach, which will ensure the integrated use of natural and social sciences and the design arts, in planning and decision making affecting the human environment. The agencies are directed to develop methods and procedures which will ensure that the unquantified environmental values are given appropriate consideration along with technical considerations. The Regional Potash Environmental Analysis Record is the BLM procedure for making a systematic and analytical assessment of the environmental impacts of potash leasing and its alternatives, as required by NEPA.

The Environmental Analysis Record (EAR) is designed to include ways of minimizing adverse environmental impacts and to document the environmental analysis for the decision maker.

The Proposed Action

The Proposed action is BLM's consideration of and the processing for approval of the following types of actions within the potash study area:

1) readjustment of existing potash leases

2) non-competitive potash lease applications

3) competitive potash lease applications

4) potash prospecting permit applications

To date, the following numbers of these actions are on file with BLM:

1) 36 lease readjustments covering 52,700 acres

2) 1 non-competitive potash lease application covering 800 acres

3) 16 competitive potash lease applications covering 26,200 acres

4) 226 potash prospecting permit applications covering approximately 533,500 acres

In addition to these applications, the potash companies have certain long range plans which will result in new or adjusted mining and reclamation plans. These plans will be submitted to USGS and will require BLM approval. A discussion of the applications, lease readjustments, and of the various company plans begins on page I-80. The assumptions made in connection with consideration and approval of the proposed action are discussed on page III-1.

Map I-1 in the back pocket of this report shows the existing potash leases and the application areas.

The purpose of the proposed action is to satisfy the Secretary's responsibility, delegated to BLM, for the orderly development of mineral resources on national resource land. The applications for the various proposed actions are generated by a demand for potassium salts as fertilizer ingredients which will help alleviate the world food shortage.

The scope of this Environmental Analysis Record is to assess the magnitude, intensity and duration of existing and potential environmental impacts (both beneficial and adverse) associated with potash resource development in the vicinity of Carlsbad, New Mexico. The geographic area of analysis (Potash Study Area) is shown on Map I-2, page 4.

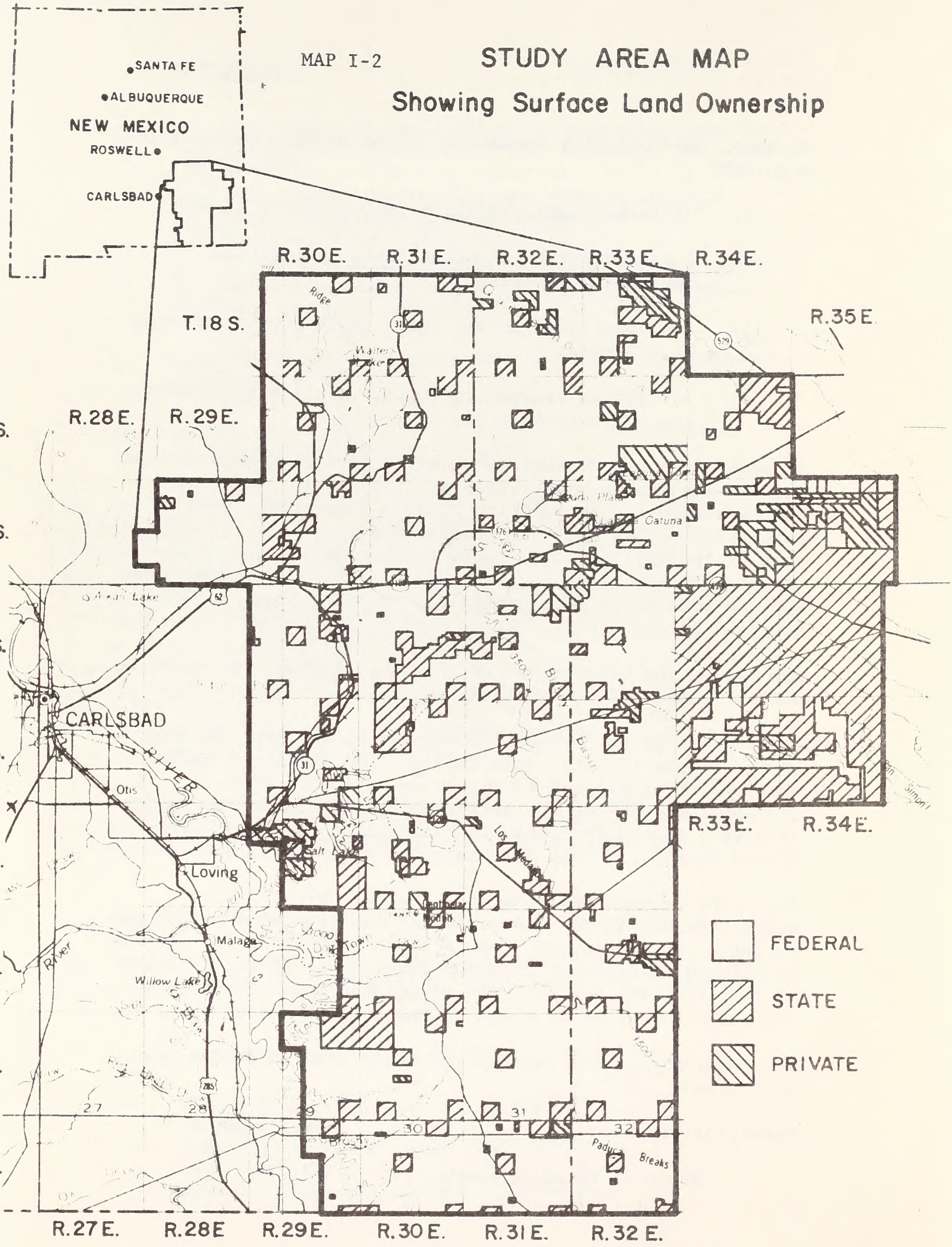
The ownership of the land in the study area is broken down as follows:

Total Surface Area	969,875 Acres
National Resource Lands	717,276 "

MAP I-2

STUDY AREA MAP

Showing Surface Land Ownership



State	167,809 Acres
Private	84,110 "
Other*	680 "
Subsurface Ownership Total	969,875 "
Federal	768,923 "
Non-Federal	200,952 "

*AEC Withdrawal for Project Gnome

See Appendix E-3 for a breakdown of surface and subsurface ownership by township.

This EAR covers an estimated 20-year projection of potash resource development.

Background

The geologic events which lead to the deposition of potash ores began late in the Permian Age, more than 225,000,000 years ago. It was a time of change when many forms of animal and plant life were being replaced by others, and the age of the dinosaurs was beginning.

During this time there was a very large and deep marine basin called the Delaware Basin, which was almost surrounded by a low reef, the Capitan Limestone (Kottlowski, 1972, p. 46). Because the basin was nearly land locked, it gradually filled with evaporite minerals. At first these minerals were mostly limestone (calcium carbonate) and anhydrite (calcium sulfate). Later, as more evaporation occurred, the dominant precipitate was halite (sodium chloride) and finally the more soluble potassium and magnesium minerals were precipitated.

For the purpose of this discussion, potash ores are ores containing the minerals sylvite (potassium chloride), or langbeinite (potassium magnesium sulfate). Other potassium minerals that may be present are referred to collectively as hydrous evaporites. These include both soluble and insoluble minerals. Prominent among the insoluble minerals is polyhalite, which includes potassium but is not considered a potash ore.

Background

A flourishing potash industry was developed in the American Colonies during the seventeenth century by early settlers who manufactured crude potassium salts by leaching wood ash in iron pots. It is from this process that the name potash was derived. Later, following discoveries of large natural potash reserves in Europe, the United States became dependent upon foreign sources. This dependence spurred both the government and private industry to seek sources within the United States. The need to discover other sources of potash became especially critical when the German supply of potash was cut off during World War I.

In the early 20th century, petroleum exploration in New Mexico's Permian Basin (Delaware Basin) revealed the widespread occurrence of evaporites, indicating that the area was of interest as a potential province for potassium mineralization. In 1925, sylvite, the primary potash ore, was discovered in New Mexico. The discovery well is the Snowden McSweeney McNutt No. 1 well in Eddy County near Carlsbad. Sylvite is a clear, crystalline potassium chloride salt, and with a sharp almost bitter salty taste. It has the approximate hardness of table salt. Sylvite is readily soluble in water and its primary use is to provide potassium for plant growth. Ordinarily it is mixed in nitrate and phosphate fertilizers for marketing.

The secondary potash ore mined in Carlsbad is langbeinite, a potassium, magnesium, sulfate salt ($K_2SO_4.2MgSO_4$). It is a clear, crystalline mineral, much harder than sylvite, tasteless, and slowly soluble in water. As a fertilizer component, it supplants sylvite for use on plant crops which are subject to damage from the chloride in sylvite.

Following the discovery of the mineral sylvite in the McNutt Well, U. S. Potash Company (property now owned by Mississippi Chemical Corporation) began an exploratory drilling program and sunk the first shaft in December, 1929. The shaft was completed in January, 1931, and the first New Mexican potash was produced in the same year. The Potash Company of America began production of potash in 1934. Union Potash and Chemical Company (now International Minerals and Chemical Corporation) began production of both sylvite and langbeinite in 1940. The two earlier companies were producing only sylvite. Duval Sulfur and Potash Company (now Duval Corporation) began the production of sylvite in 1951. In 1964, Duval Corporation also started producing langbeinite. The fifth producer of potash was Southwest Potash Company (now Amax Chemical Corporation). Their sylvite production began in 1952. National Potash Company began sylvite production in 1957, and Kerr-McGee Chemical Corporation began sylvite production in 1965.

At present there are seven companies mining and refining potash in New Mexico: Mississippi Chemical Corporation, Potash Company of America, International Minerals and Chemical Corporation, Duval Corporation, Amax Chemical Corporation, National Potash Company and Kerr-McGee Chemical Corporation. These seven companies which produce all of New Mexico's potash, are operating 24 hours a day within the Carlsbad potash study area. These producers along with the Kerr-McGee operations at Searles Lake, California account for about 92 percent of the domestic production. The remaining 8 percent comes from Salduro Marsh in Utah (Bonneville Limited), the Great Salt Lake in Utah (Great Salt Lake Mineral and Chemical Company), the wells of Dow Chemical Company at Midland, Michigan, and from the Texas-Gulf mine near Moab, Utah.

In 1967, Canadian potash firms began producing potash at low costs and selling it on the American market at prices which were lower than established competitive rates. This caused a severe cutback in New Mexican potash production. Since the domestic potash industry was injured, duties were assessed on potash imported from Canada. The Canadians then placed a production quota on their potash which subsequently caused a rise in Canadian potash prices. This rise in price put the New Mexican potash industry on a competitive basis with Canadian sources.

While the Carlsbad potash production is used principally in the manufacture of fertilizer, sylvite refined to a high state of purity is used in the manufacturing and chemical industries to make glass, explosives, pharmaceuticals, soaps, and many other products.

In 1938, the last normal year prior to World War II, New Mexico potash production was 535,000 tons of potash salts, equivalent to 317,000 tons of potassium oxide (K_2O). By 1973 production had increased to 3,960,000 tons of salts, equivalent to 2,250,000 tons of potassium oxide. (For discussion of potassium oxide measurements, see Appendix A-13.)

Background

Most potash is mined from lands owned by the State or Federal Government. For this privilege, a royalty on the production is paid. Of royalties paid to the Federal Government, 37.5 percent is returned directly to the State, 10 percent is allocated to the general fund of the Federal Treasury, and 52.5 percent is allocated to the U. S. Bureau of Reclamation, which follows the policy of spending this money in the State from which it came. Thus, New Mexico receives the benefits of 90 percent of the federal royalties, in addition to all of the royalties from state leases.

The long range outlook for the potash industry in New Mexico appears to be favorable because of a strong demand for fertilizer to meet the growing world food shortage.

I. Description of the Proposed Action and the Alternative

A. Scope

The statutory structure for issuing potash prospecting permits and leases is such that the permittee and lessee obtain rights to use the surface and subsurface estate as necessary to mine and refine the potash for market. In view of the rights which are granted, the government must recognize that a potash mine and/or refinery may be constructed and operated on any area where a permit or lease is granted. Therefore, it is essential to describe a typical potash operation.

All potash operations in the Carlsbad Potash Basin are basically similiar with few minor variations in the various internal refining and mining processes. This analysis will first describe a typical potash operation, which includes exploration, mine development, mining, refining, support facilities and lease abandonment.

With this broad picture of potash mining and refining, the reader should be able to visualize what takes place from the time exploration starts until the end product is manufactured, and the lease is abandoned.

1. Typical Potash Operations

a. Exploration

Exploration, the first process in a typical potash development operation, determines the quality and quantity of a potential ore reserve by the drilling of test holes which yield ore samples for examination.

(1) Roads

The first step in this process is the locating of existing roads and/or the construction of new one-lane access roads to the proposed drill pad site. Usually, existing roads are used wherever possible. Sometimes an existing road has to be bladed and new roads often have to be surfaced with caliche, a mineral material, which is abundant locally. This surfacing is necessary because of the sandy nature of the soil. Roads to the drill site are used to transport a truck mounted rotary drill rig, a tank truck, logging units, bulldozers, personnel carriers, and several other smaller transport vehicles.

(2) Drill Pads

The second step in the exploration process is the construction of the drill pad, i.e. the ground surface surrounding the test hole. The number of drill pads for any specific exploration effort ranges from 1 to 16 pads per square mile with an average of 3 drill pads per square mile. The number of test holes primarily depends on the consistency of information gathered in previous test drilling and/or mining.

A crawler tractor with a dozer blade is normally employed to level a drill pad area of about 100 by 100 feet. Actual surface disturbance covers slightly more ground because of the berm (extra dirt) pushed off the drill pad for leveling.

In addition, a sump pit is constructed on each drill pad to contain drill cuttings and fluids which are circulated and returned to the drilling operation. These small sump pits average about 15 feet long, 5 feet wide and 5 feet deep. Because brine liquids and oil bearing liquids are used during drilling, the pits are lined with a heavy plastic material to prevent soil contamination.

(3) Drill Equipment

The drill rig or system used in modern exploration consists of a self-propelled, truck-mounted, drill unit equipped with the necessary supporting systems such as hydraulic systems, pumping units, and lighting systems, all powered by the truck engine. In exploration for potash ore, most exploratory drill rigs are capable of reaching depths of 2,000 feet below land surface without great difficulty. A tank truck equipped with suitable racks supplies the drilling fluid (either water, brine or diesel) and often serves to store drill pipe during drilling and to transport pipe when the drill rig is moving to a new drilling location.

Drill rigs are rotary types needed to turn the hollow rock cutting bits because solid cores from the rock formations are generally desired for direct observation and analysis.

In the coring technique, a hollow cutting bit and core barrel assembly is mounted on the end of a string of drill pipe. The drill string is lowered from the rig into the drill hole and turned by the rotary table at the surface. At the same time, the pumping units at the surface circulate drilling mud down the hole to the bit and then back to the surface. The drilling mud or media serves to carry away the rock cuttings produced during drilling, cools the cutting bit, and maintains pressure at the bottom and sides of the drill hole to minimize caving.

The bit used for cutting core is commonly a diamond bit consisting of a tungsten-alloy and a thick-wall cylinder with numerous diamonds fixed to the bottom and sides to form the cutting surfaces. Drilling advance through solid rock is by the abrasive action of the diamond bit against the softer rock. Excessive weight increase on the bit by the attached drill string or the hydraulic system at the surface will fracture the diamonds rather than increase the cutting rate through the rock.

The solid core of potash-bearing rock obtained by drilling can be directly observed and analysed; and a determination can be made regarding mineral resources and reserves. Consequently, plans can be made for mining or avoidance of the area of influence which the core represents. Holes are drilled through the overlying soils and bedrock which is composed mostly of mudstone, gypsum, and dolomite beneath the soil and overlying the salt. The drill hole is futher drilled through the thickness of common salt with or without the taking of core, but when the potash-bearing beds of rock are encountered or approached, cores are taken.

After the drilling location is determined, the access road, drill pad, and sump are constructed as described above. All extraneous surface materials are removed from the road and pad to assure constant access and manueverability for the large, heavily loaded trucks. On location, the drill rig is leveled to enable the drill hole to be maintained nearly vertical from the surface to total drilling depth. On level drill pads the levelling is fairly simple but on inferior pads much jacking and digging in may be required. Pits or sumps are filled with water, and connected by hoses to the pumps. The drill rig and coring apparatus are then assembled, set up, and drilling proceeds.

(4) Drilling Operations

In potash exploration and development drilling, fresh or brackish water is used as drilling media from the land surface to the top of the salt. These relatively unmineralized waters help to minimize possible contamination of fresh or brackish water zones encountered in drilling. Drilling mud may be added at the outset to inhibit fluid exchange among the drill hole, water-bearing rock beds, and rock beds which transmit water with relative ease. The very fine-grained cuttings as a result of drilling normally stay entrained in the circulation of the drilling media or mud and contribute to mud density. The mud density is controlled at the surface by the addition of water or mud. Water is supplied by the tank truck shuttling between the water supply point and the drill location.

Upon reaching the top of the salt section in which the potash-bearing beds are contained, the operator changes the drilling media to salt-saturated brine. This brine is added to the sump to prevent excessive solution of the salt beds and resulting increase in hole diameter. Although more salt will not now enter into solution in the brine, the soluble potash-bearing minerals are subject to solution action. This solution action prohibits the recovery of solid cores of potash-bearing rock and a replacement of the drilling fluid is required. At a known point or marker bed in the salt section above the potash-beds being tested, the brine is flushed out of the system, trucked to a brine disposal area, and replaced by diesel. Both salt and potash-bearing minerals are of limited solubility in diesel. Therefore, solid cuttings and cores can be recovered in this drilling media.

From land surface to the top of the salt, the hole is drilled with a rock bit. Cuttings and cores are not normally taken. The depth to the top of the salt is about 500 to 800 feet in most places but in some places is over 1,000 feet. When the top of the salt is encountered the drill string is pulled to surface and the hole is cased with steel casing seated in the salt at the bottom. Casing is normally about six inches in outside diameter, or a sufficient diameter to permit the use of smaller diameter tools within the casing. The steel casing isolates the rock above the salt from the brine-base drill fluids to be used in hole advance and thus prevents brine and diesel contamination of rock above the salt. The casing also supports the sides of the drill hole.

At the top of the salt, either rock or core bits can be used, depending upon the operator's knowledge of the depth and continuity of the potash ore zones. Either at the top of the salt or at a market bed within the salt, the rock bit is replaced by a core bit. When the core barrel behind the bit is full, the drill string is pulled and the core removed. The wireline system allows the core to be retrieved in a tube section that is pulled to the top of the hole through the hollow drill pipe. This core retrieval method allows the drill string and core barrel assembly to stay in the hole for the life of the bit, a technique which provides savings by increasing the available drilling time.

The core segments are placed in boxes in the same order as the core came out of the hole, thus providing a sequential record of the rocks penetrated. The core is then available for observation, logging and testing.

At total depth, the drill rig is placed on standby status and the hole is logged electrically. Intensity of gamma radiation is usually recorded and neutron response and resistivity of the rock may also be recorded. Electric logs are taken to record the radioactivity of potassium 40, and to thereby aid in mapping potash beds.

(5) Reclamation

Reclamation is the last phase of exploration. The diesel in the hole and sump is removed by tank truck for further use in drilling. Cement slurry is pumped into the hole and circulated to the surface to ensure that the hole is completely filled, sealed and neutralized, and the steel casing is pulled from the hole. The plastic sheet is removed from the sump, and stored and final clean up of the site commences. The drill rig and supporting equipment is now disassembled and moved off location in preparation for moving to another drill site. A standpipe, tall enough to be surveyed and bearing a brass cap, is placed on the hole. The hole is precisely surveyed and the location is stamped in the cap, thereby marking the hole for future recovery and use in the field.

A bulldozer is moved on the drill site and scarifies and destroys the drill pad by returning the soils to contour. The sump is restored to grade by returning fill material to the sump and the area is further smoothed to conform to existing minor topography at the site.

If there is to be no further use of the access road, it also would normally be scarified, water barred and allowed to revegetate naturally.

b. Mine Development

The selection of the proper size, configuration, arrangement and type of openings required for the extraction of ore from an underground mineral deposit is an extremely complex engineering problem. Each mineral deposit has distinct features requiring separate analysis. Mine openings for development and extraction of ore are classified according to principal purpose such as: (1) production, (2) service, (3) ventilation, (4) development, and (5) a combination of production and service.

Shaft openings are usually circular or rectangular in shape and must have basic ground support systems consisting of one or more of the following: (1) concrete, (2) timber sets, (3) steel sets, (4) rockbolts, and (5) steel liners.

Each shaft is arranged to accomodate internal items such as utility lines, ladders, landings, sets, skip and cage guides, track, ore skips, personnel and material cages, auxiliary emergency escape cages, and conveyors. Gross internal arrangement is accomplished by compartmentalization of the shaft.

Shafts are designed to achieve the optimum in the way of (1) safety, (2) lowest capital and operating costs, (3) dependability, (4) efficiency, (5) flexibility, (6) conformance to the mining plan, and (7) fast construction.

After the shaft location is determined with respect to design criteria, the company decides whether to do its own construction work or to hire a contractor for the shaft construction. Present trends indicate that operators prefer to deepen existing shafts or sink new shafts for developing additional ore within an existing mine. Contractors perform about 75 percent of conventional shaft construction in the United States.

(1) Bored Shafts

Vertical and inclined circular shafts can be constructed either by boring or conventional shaft sinking methods. Bored shafts are constructed primarily for ventilation and for emergency escapeways. These shafts are seldom used as a sole means of developing and producing a mineral deposit because of the small diameter capability of available boring equipment. The average bored shaft diameter is about 6 feet, although bores as much as 25 feet in diameter have been completed.

Mechanical boring machines are used to construct bored shafts. These machines have mounted cutters which break the rock by abrasive or shearing action. Thrust to the cutting heads and force on the rock face is applied through thrust jacks, or through the weight of a drill string. Construction of a bored shaft to an existing mine permits the cuttings to be dropped into the mine and removed by conventional mining methods. Cuttings can be dropped in existing mine workings either by boring upward from the workings (raise drill) or boring downward from the surface, with the guidance of a pilot hole. All other boring methods require that cuttings be removed from the collar of the bore at land surface. Bores are advanced from the surface by methods similar to conventional drilling techniques, but drilling equipment and cutting heads are much larger. Bored shafts may be left without ground support because the relatively small diameter and circular configuration adds inherent stability to the opening.

Some of the rock in which shafts are bored is soft and subject to weathering with the result that many bored shafts are lined with a steel liner. The liner is generally grouted into position to add stability and to exclude surface and ground water from the shaft.

(2) Conventional Shafts

Conventional shafts are generally one of the following (1) rectangular shafts with timber sets, (2) rectangular shafts with steel sets, (3) rectangular shafts with reinforced concrete lining, and (4) circular shafts with concrete lining.

Rectangular timbered shafts are divided into compartments by timber sets. Figure I-1 shows layouts of typical multicompartment timbered shafts and figure I-2 shows a typical timber detail of a three compartment timbered shaft.

Rectangular steel set shafts are divided into compartments in the same manner as with timber sets. If concrete lining is used, then steel walls and end plates are omitted from the sets and the steel dividers are fastened to the concrete by brackets and inserts or by block-out supports formed in the concrete lining. Figure I-3 shows typical layouts for steel set shafts and figure I-4 shows a multicompartment steel set detail. Circular shafts lined by non-reinforced concrete for ground support are divided into compartments by structural steel sets. Compartment arrangements are dependent upon the purpose of function of the shaft. Figure I-5 shows typical circular shaft arrangements.

Principal equipment items necessary for conventional shaft sinking are (1) production or sinking hoist, (2) headframe, (3) auxiliary winches and rope, (4) production skips, (5) skip scrolls and head sheaves (6) shaft steel sets, guides, and lining, (7) skip loaders, and (8) a shaft skip spill system. Provision must also be made for doors at the top of the shaft (collar doors), shops, offices, and change room facilities at the site. Electric power and communications must be brought on site from outside or provision made internally for generation of electricity and a radio-communication system.

The main sinking hoist is constructed about 120 feet from the shaft. If the installation is to be permanent, the production hoist can be used to sink the shaft if it is adaptable to sinking equipment. Single drum hoists are commonly used for shafts ranging from 1,200 to 1,500 feet in depth. Cycle times are improved by double-drum

COMPARTMENT	ARRANGEMENT	OUTSIDE TIMBER SIZE		EXCAVATED SIZE		VENTILATION AREA Ft²
		DIMENSIONS (IN.)	AREA Ft²	DIMENSIONS (IN.)	AREA Ft²	
2 Compartment	H MW	74 x 138	71	98 x 162	110	41
3 Compartment	H H MW	74 x 202	104	98 x 226	154	61
4 Compartment	H H CP MW	74 x 266	137	98 x 280	191	81
5 Compartment	H H V CP MW	74 x 330	170	98 x 354	241	101

Assumptions

1. Compartment Size:
   4.5 x 4.5 ft
2. Timber Size: 10 x 10 in.
3. Set Spacing: 5.5 ft
4. Guide Size: 4 x 6 in.

Arrangement Key

H = Hoisting Compartment
MW = Manway Compartment
CP = Chippy Compartment
V = Ventilation Compartment
C = Cage Compartment
P = Pipe Compartment

Compartment Layout (Hoisting)

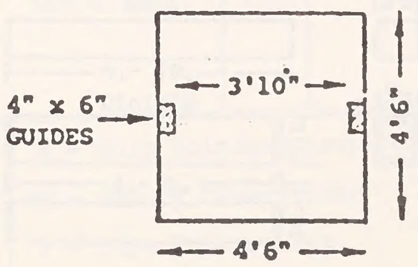


FIGURE I-1 Typical rectangular timbered shaft arrangements

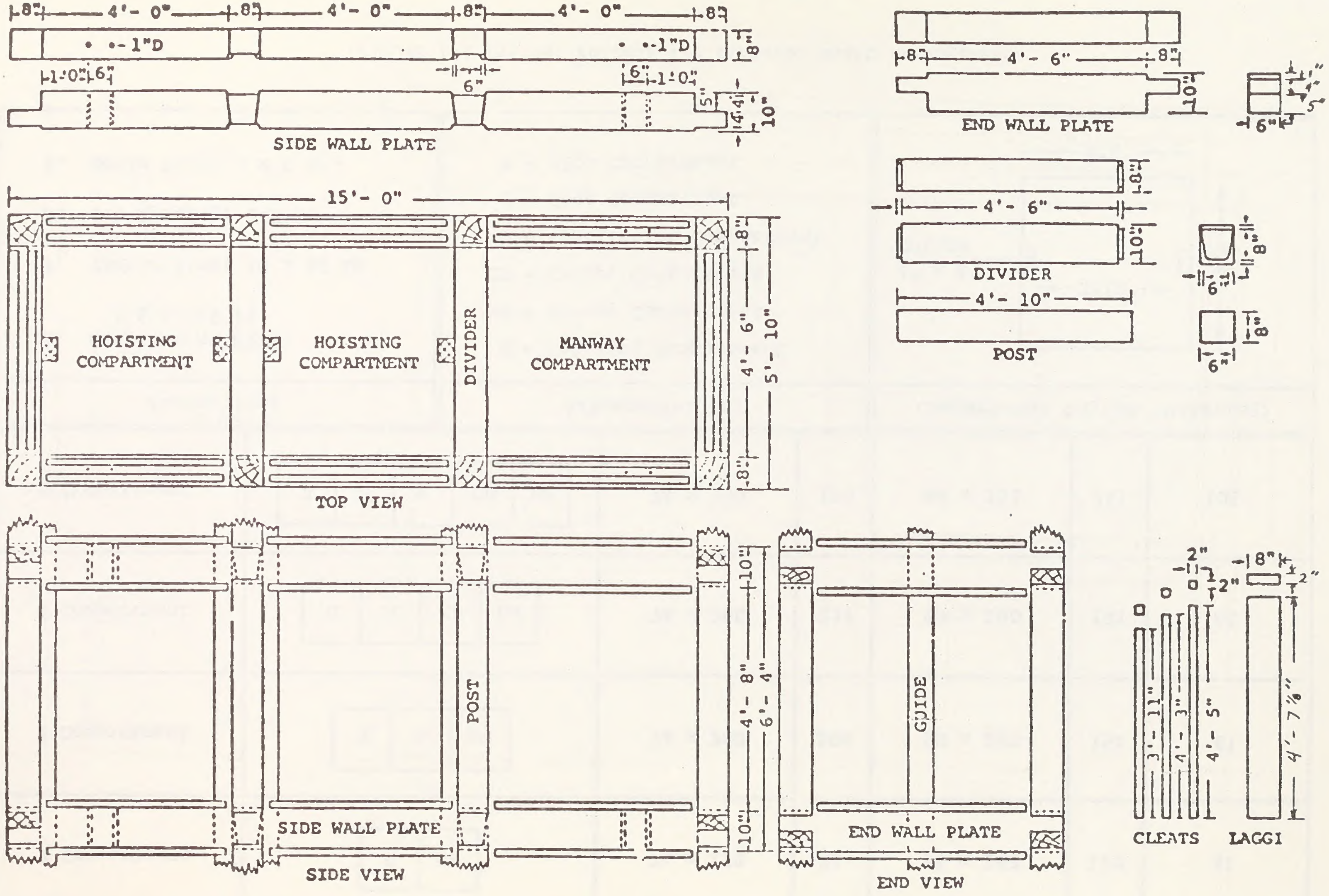
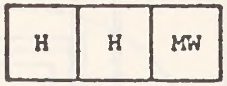
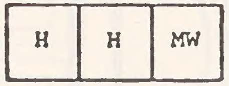
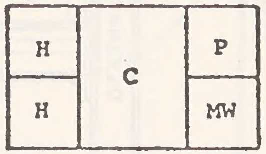
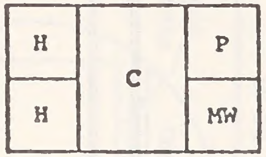


FIGURE I-2 Three-compartment shaft timber detail

COMPARTMENT	ARRANGEMENT	INSIDE LINING OR OUTSIDE STEEL SIZE		EXCAVATION SIZE		VENTILATION AREA Ft.^{2}
		DIMENSIONS (IN.)		DIMENSIONS (IN.)		
3 Compartment with Concrete Lining		82 x 230	130	106 x 254	187	91
3 Compartment without Concrete Lining		66 x 214	98	90 x 238	149	91
5 Compartment with Concrete Lining		156 x 254	275	180 x 278	348	208
5 Compartment without Concrete Lining		140 x 238	231	169 x 262	298	208

Assumptions	1. Compartment Size: 5.5 x 5.5 ft & 7.5 x 11.75 ft 2. Steel Set Size: 8WF31 3. Guide Size To LB: ASCE Rail 4. Set Spacing: 10 ft 5. Lining Thickness: 12 in.	Arrangement Key	H = Skip Hoisting Compartment MW = Manway Compartment P = Pipe Compartment C = Cage Compartment

FIGURE I-3 Typical rectangular steel set shaft arrangements

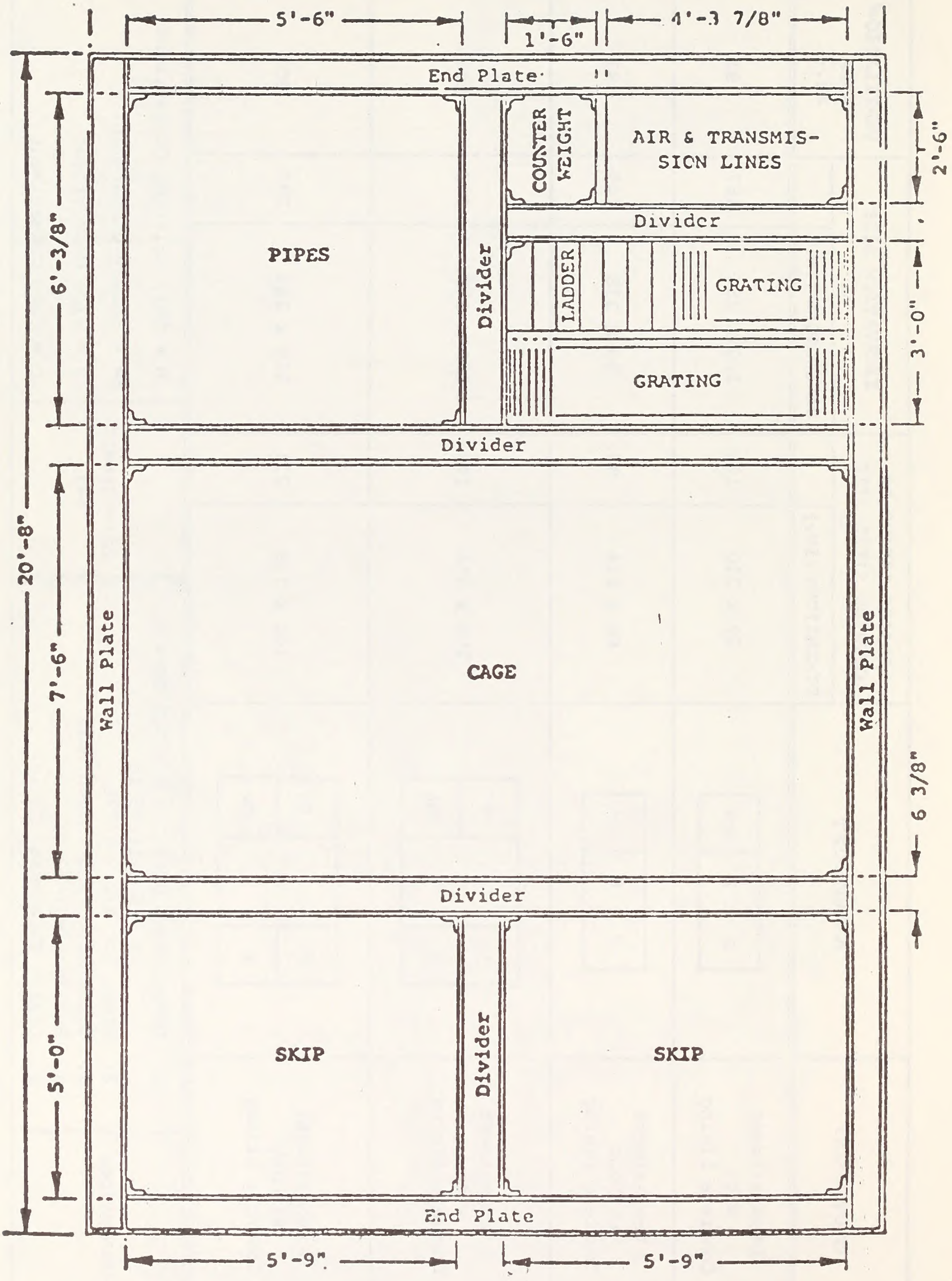
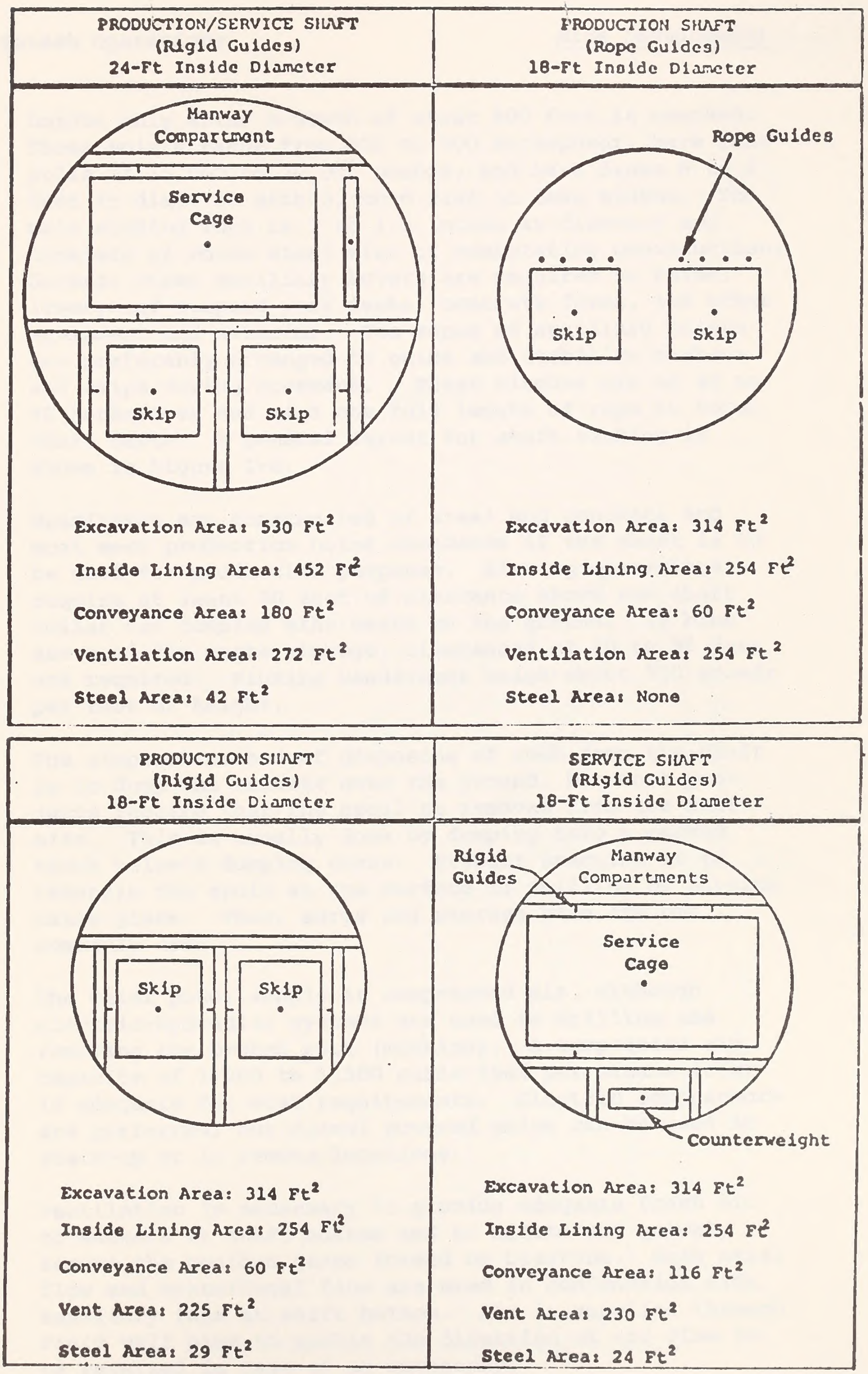


FIGURE I-4 Five-compartment steel set shaft detail



PRODUCTION/SERVICE SHAFT
(Rigid Guides)
24-Ft Inside Diameter

Excavation Area: 530 Ft^2
Inside Lining Area: 452 Ft^2
Conveyance Area: 180 Ft^2
Ventilation Area: 272 Ft^2
Steel Area: 42 Ft^2

PRODUCTION SHAFT
(Rope Guides)
18-Ft Inside Diameter

Excavation Area: 314 Ft^2
Inside Lining Area: 254 Ft^2
Conveyance Area: 60 Ft^2
Ventilation Area: 254 Ft^2
Steel Area: None

PRODUCTION SHAFT
(Rigid Guides)
18-Ft Inside Diameter

Excavation Area: 314 Ft^2
Inside Lining Area: 254 Ft^2
Conveyance Area: 60 Ft^2
Vent Area: 225 Ft^2
Steel Area: 29 Ft^2

SERVICE SHAFT
(Rigid Guides)
18-Ft Inside Diameter

Excavation Area: 314 Ft^2
Inside Lining Area: 254 Ft^2
Conveyance Area: 116 Ft^2
Vent Area: 230 Ft^2
Steel Area: 24 Ft^2

FIGURE I-5 Typical circular shaft arrangements

hoists only after a depth of about 800 feet is reached. These hoists range from 400 to 900 horsepower, have line pulls of 15,000 to 20,000 pounds, and have drums 6 to 8 feet in diameter with 3, to 6 feet in face widths. The main sinking rope is 1 to 1.5 inches in diameter and consists of woven steel wire of nonrotating construction. Several other auxiliary hoists are required to raise, lower, and suspend work decks, concrete forms, and other equipment and material. The ropes of auxiliary hoists are preferably arranged to guide and stabilize buckets and skips during movement. These winches are of 20 to 40 horsepower and wind one full length of rope to total shaft depth. A general layout for shaft sinking is shown in Figure I-6.

Headframes are constructed of steel and concrete and must meet production hoist standards if the shaft is to be used for production purposes. Sinking operations require at least 50 feet of clearance above the shaft collar for dumping mine waste on the ground. If bins are used for waste storage, clearances of 70 to 95 feet are required. Sinking headframes weigh about 900 pounds per foot of height.

The simplest method of disposing of rock from the shaft is to dump the buckets onto the ground, but most projects require that the spoil be removed from the shaft site. This is usually done by dumping into a parked truck below a dumping chute. Present practice is to rehandle the spoil at the surface if spilling or surging takes place. Thus, surge and storage bins are not commonly used.

The chief power supply is compressed air, although electric-hydraulic systems are used in drilling and removing the broken rock (mucking). A compressed air capacity of 1,200 to 1,500 cubic feet per minute (cfm) is adequate for most requirements. Electric compressors are preferred, but diesel powered units can be used in start-up or in remote locations.

Ventilation is necessary to provide adequate fresh air to workers at shaft bottom and to dilute and quickly remove the noxious gases formed by blasting. Both axial flow and centrifugal fans are used in conjunction with auxiliary fans at shaft bottom. Air is supplied through rigid wall pipe to enable the direction of air flow to be reversed in case of an emergency.

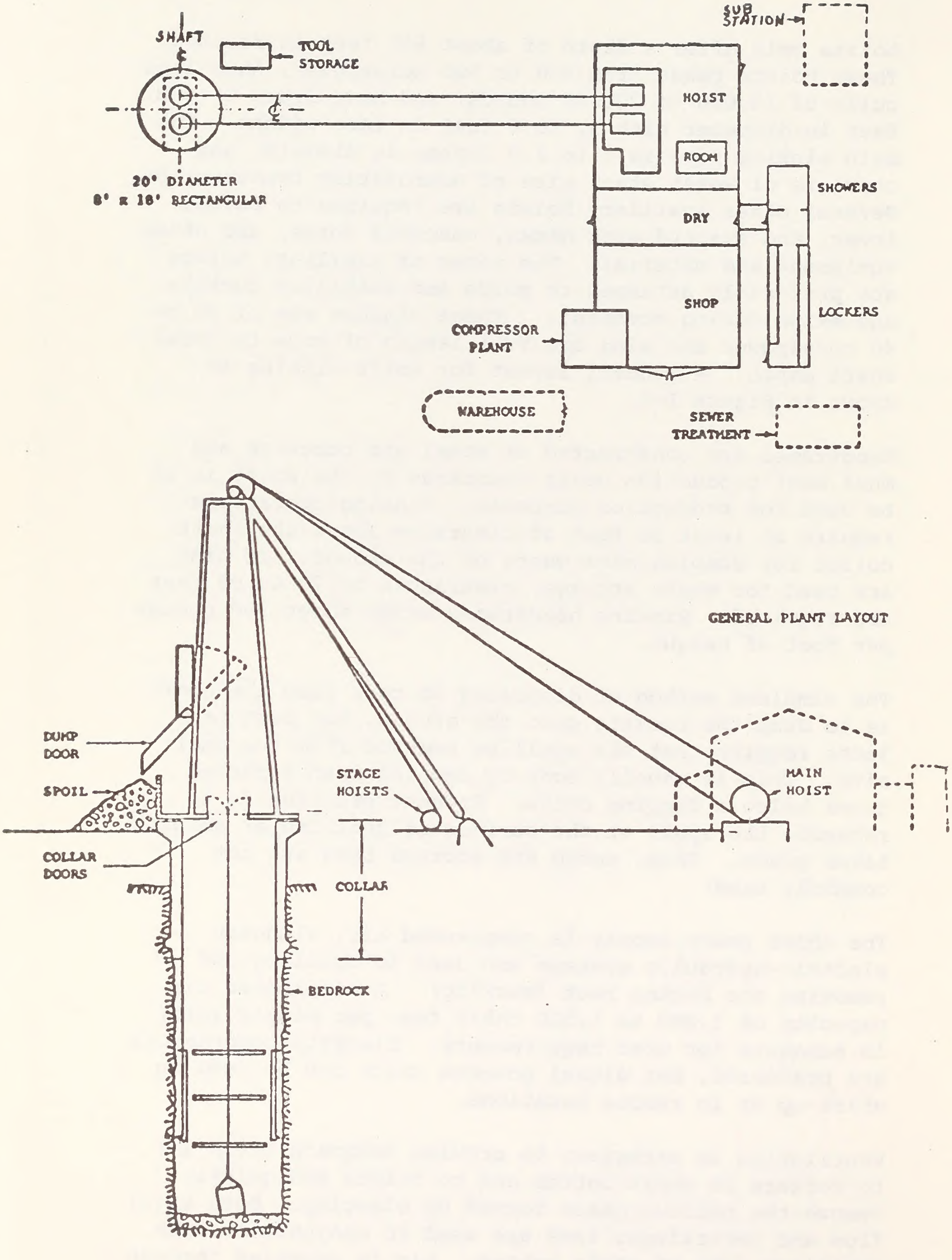


FIGURE I-6 General plant layout for shaft sinking hoist

Shaft sinking is started by collaring the shaft, a work sequence of construction of the shaft collar or the upper shaft section which penetrates overburdened and weathered rock. The surface is cleared and the soil excavated before sinking begins. The concrete collar walls are about 30 to 40 feet in depth and extend upward a few feet above the surface from keyed footings in competent bedrock. Once the collar is established, the shaft is deepened about another 60 feet to allow room for installation of hardware and equipment. Concrete forms are positioned, work decks lowered, and the headframe is then set on the collar. Auxiliary hoists are fixed, hoisting ropes attached to forms and stages, and the collar grouted to prevent surface water seepage into the shaft.

Drilling for blasting is done mostly by percussion drills mounted on 4 and 5 boom jumbos. Auger and rotary drills can be used in softer rock. Hole diameters are usually about 1.5 inches. Hole length in rectangular shafts is about 8 feet which allows an advance of 3.5 to 4 feet per blast. Shafts can be advanced by benching or mining full face. Most circular shafts are not benched and hole lengths are greater.

Semigelatin explosive is the most widely used blasting agent in shaft work because it is positive under wet conditions and can be loaded easily in small diameter holes in cold weather. Shaft blasting commonly requires electric blasting detonators in series or parallel circuits fired from the surface. After blasting in the bottom of shafts, spoil or muck must be lifted and loaded upward from a confined working space. For shallow shafts, the clamshell excavator working from the surface has been adapted for spoil removal. For deeper shafts, mucking and loading machinery is suspended below the working stage such that it can be pulled upward away from blasting and lowered for mucking operations.

Shafts are lined on advance after muck removal. Timber sets are suspended beneath the previous set by hanging rods and at predetermined intervals are keyed into the shaft wall by bearing timbers set in rock hitches. Concrete forms are rigged on the bottom or suspended. Once the forms are in place, concrete mixed on-site or received ready-mixed is poured into a hopper which feeds the 6 inch diameter slick line extending down the shaft to the elephant trunk, a flexible hose which is moved around the shaft to distribute the concrete evenly. The poured concrete is vibrated by form or pneumatic hose vibrators to assure a concrete strength standard of 3,000 to 3,500 pounds per square inch in 28 days.

Some water is always present in a shaft and pumps must be available for emergencies. Second-line pumping systems should be on standby in the event of failure of first-line pumps. Occasional water flow can be adequately handled by steady pumping and dewatering of the rock adjacent to the shaft. In some instances it is necessary to dewater the rock around the shaft by pumping large quantities of water from relief wells drilled around the shaft perimeter. The shaft perimeter and adjacent rock can also be grouted, thereby setting up a cement curtain between the shaft and surrounding saturated rock.

(3) Freeze Drilling

In places, heavily water laden gravel, sand, silt, and clay may be encountered either near the land surface or perhaps under high pressure hundreds of feet below the surface. These water saturated, unconsolidated rock beds are particularly troublesome in shaft sinking operations because they flow to fill the shaft void immediately upon penetration, and in many places cannot be successfully retained by normal construction methods such as shoring or use of retaining structures down the shaft. In most places relief wells and grouting are used to protect the shaft from the effects of large flows of water and/or unstable ground. If relief and grouting methods fail, the water flow can be stopped and the ground can be stabilized by freezing for the duration of shaft construction through the saturated and unconsolidated parts of the rock section.

Most unconsolidated rock material occurs near and at land surface. Near the surface, soils can be penetrated by freeze points and frozen from the surface. Similarly, rock beds at depth can be penetrated from the surface but the required drilling may greatly increase costs.

Where costs of drilling for freezing are exorbitant, freeze stations are excavated in the shaft at safe distances above the saturated beds and the freeze points drilled through the bed from the station.

Drill holes which will serve as freeze points are drilled in concentric circles about one shaft diameter from the shaft center. Holes are closely spaced and precisely surveyed where possible to assure uniform freezing and ice build up in the rock beds. Drill holes penetrating these unstable beds can be kept open by high-density drilling mud until the casing can be seated in the hole. Dual casing strings are seated to serve as a conduit within which the coolant is circulated. The outer string is plugged at bottom and both strings are rigged through a pressure gland at the surface. Thermocouples for the monitoring of temperatures are implaced at the top and bottom of freeze-point holes and also in holes in the shaft center and elsewhere.

Coolants and refrigeration systems commonly used are calcium chloride or lithium chloride brines circulated through high capacity centrifugal or rotary compressors using freon or ammonia refrigerants. Refigerating units are always at land surface. Coolants are directed to freeze points by piping and supplied or collected through manifolds constructed on site for the particular configuration of points being used.

Coolants are circulated until the ground is frozen and stable. Then the shaft is advanced by conventional methods. Freezing is maintained until the shaft lining is in place at required strength. When the shaft is completed and lined through the unstable ground, thawing is allowed to take place slowly to minimize temperature and structural shock to the lining and the ground.

The area required for shaft sinking exclusive of access roads, utilities, and muck disposal is not more than 40 acres. The area which must be cleared of vegetation and soils is considerably less. Shafts constructed by boring rather than conventional methods demand even less area. The area used for the construction of main production shafts is customarily incorporated into the production and refining complex at land surface and becomes part of the total area requirement. The rock wasted from shaft sinking is removed from the shaft site and placed in the waste area.

Estimated shaft construction schedules for circular concerete-lined shafts 12 to 28 feet in diameter constructed by conventional methods are shown in Figure I-7. Average schedule time for these same shafts is shown in Table I-1 and each operation as a percent of scheduled time is shown in Table I-2. These estimates are generally applicable to rectangular shafts requiring removal of like volumes of rock (154 to 707 cubic feet per linear foot of shaft advance) because drilling, mucking, form placement and removal, and pouring concrete require 63 to 69 percent of total time exclusive of mobilization and demobilization. Total construction time for shaft construction in the Carlsbad mining district could be as little as 30 weeks for a shallow small-diameter shaft or more than 1.3 years for a deep multicompartment large-diameter shaft.

(4) Access Entries

The potash ore bodies in the Carlsbad area are generally tabular with a slight easterly dip.

In order to reach the potash ore zone to be mined, two shafts are normally sunk. One shaft is used for hoisting ore and the other for the transportation of men and materials from the mine to the surface. The two shafts also serve as intake and exhaust air courses for mine ventilation. Figure I-8 shows a typical potash mine and included shafts in profile. A total of 25 shafts have been sunk in the potash area ranging in depths from 764 feet to 1,700 feet. The older shafts in the area were approximately 6 by 18 feet rectangular shafts. The later shafts have been circular with diameters ranging from 3 to 20 feet. The shafts are normally lined with concrete into the Salado salt formation.

A shaft pillar is left to protect the shaft and only development necessary for mining is done in the immediate area surrounding the shaft. This development is limited to a pocket for ore storage, shops, fan, and access entries to the ore body. (See Figure I-9 for a typical mine lay-out.)

Once the access entries have been driven through the shaft pillar, a series of main entries are developed.

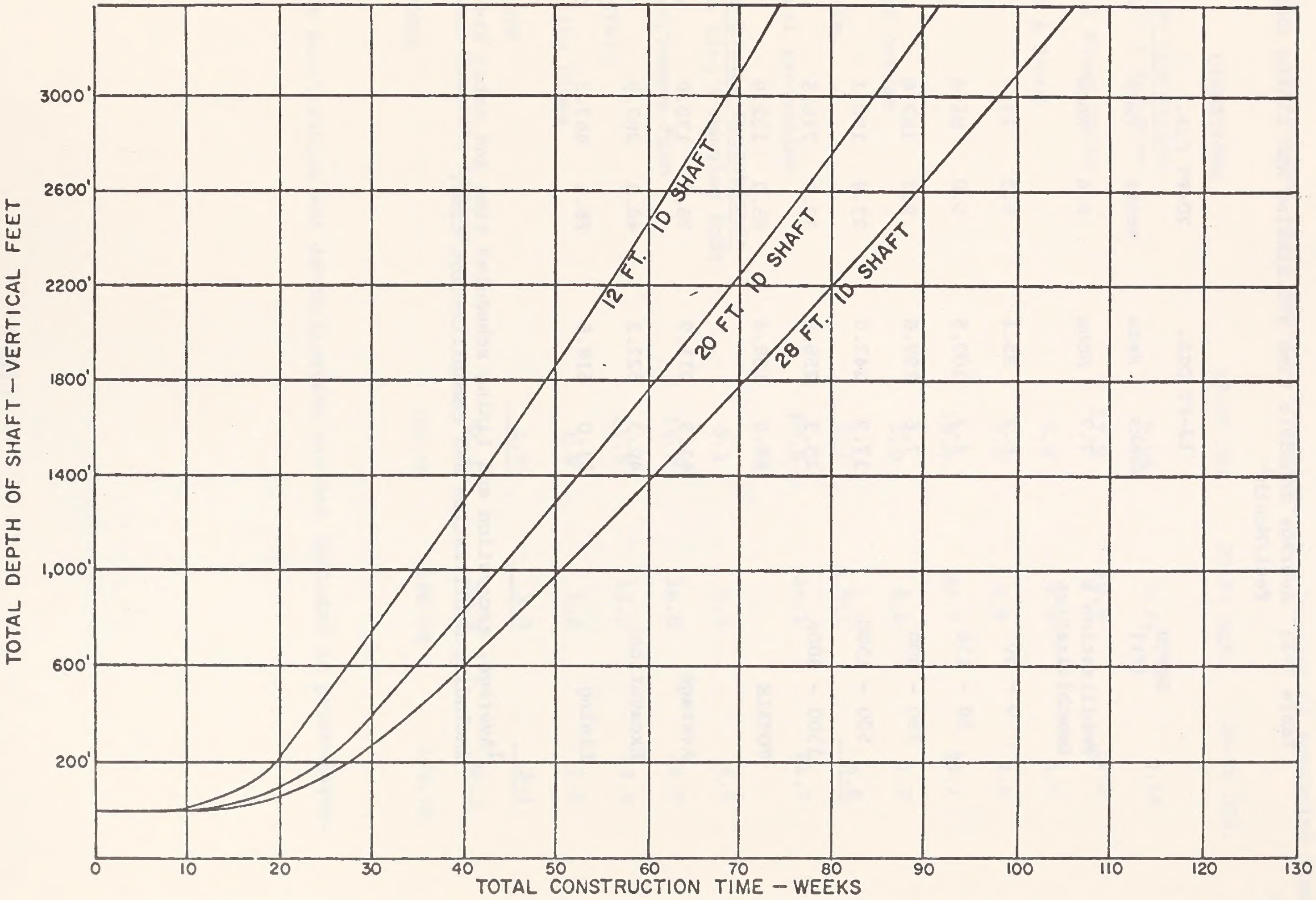


FIGURE I-7- *Construction schedule, conventional circular concrete-lined shafts*[1]

[1] Does not include equipment.

Table I-1: Average Schedule Time and Sinking and Lining Rates, Vertical Feet/Month[1]

DEPTH (Ft)	12-FT DIA.		20-FT DIA.		28-FT DIA.	
	Weeks	Rate	Weeks	Rate	Weeks	Rate
Mobilization & Demobilization	7.7	None	8.6	None	9.3	None
0 - 50	6.2	35.1	9.3	23.4	10.3	21.3
50 - 150	4.3	100.5	5.0	86.6	6.4	67.5
150 - 500	7.6	199.6	9.3	162.8	11.4	132.9
500 - 1500	17.9	242.0	22.8	190.1	25.9	167.1
1500 - 3000	25.3	256.8	30.0	216.5	34.7	187.1
TOTALS	69.0	188.4	85.0	152.8	98.0	132.5
Average	61.3	211.9	76.4	170.0	88.7	146.4
Excavation	40.3	322.3	48.3	267.9	54.7	237.5
Lining	21.0	618.6	28.1	462.3	34.0	382.1

[1] Average, excavation and lining scheduled time and rates are computed without including mobilization and demobilization time.

Table I-2: Conventional Shaft Sinking Operations as a Percent of Scheduled Time[1]

OPERATIONS	12-FT DIA.	20-FT DIA.	28-FT DIA.
Excavation Operations:			
1. Set-Up & Bar-Down	5.0%	3.2%	3.1%
2. Drill Blast Holes	17.9	14.9	14.2
3. Load & Shoot	5.4	4.6	5.2
4. Vent	6.2	2.8	2.8
5. Muck	19.4	27.7	28.1
6. Clean Bottom	5.0	4.2	3.7
7. Delays	6.7	5.7	4.6
Total Excavation	65.6	63.1	61.7
Concrete Lining Operations:			
1. Curb Ring & Hanging Rods	5.1	6.3	6.5
2. Place/Remove Form	14.2	14.0	13.0
3. Concrete	11.5	12.5	13.9
4. Utility Lines	1.8	1.5	1.8
5. Delays	1.8	2.6	3.1
Total Concrete Lining	34.4	36.9	38.3
GRAND TOTAL	100.0%	100.0%	100.0%

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[1] Project mobilization and demobilization are not included in percentages.

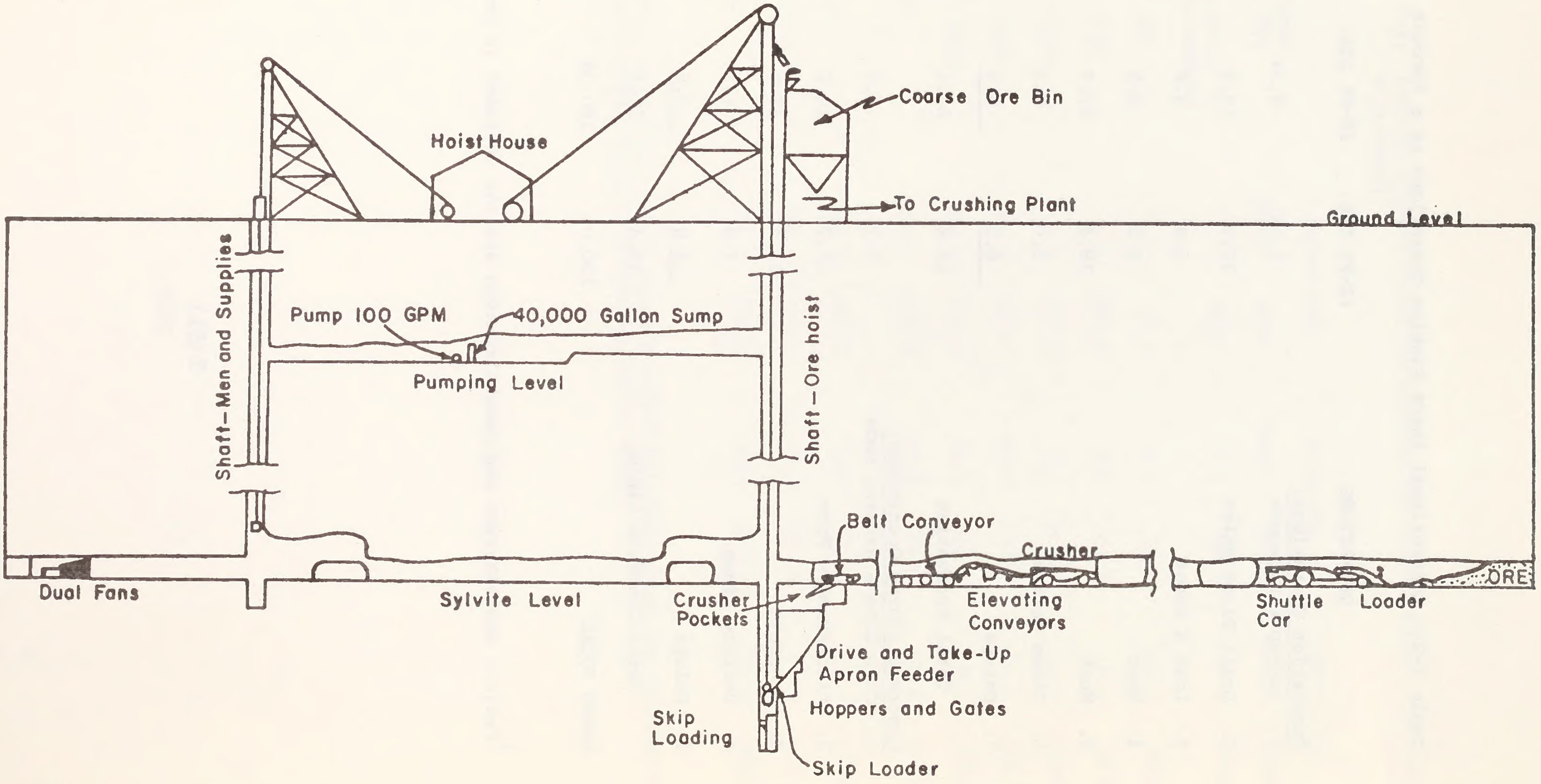


FIGURE I-8 Profile of a Typical Potash Mine

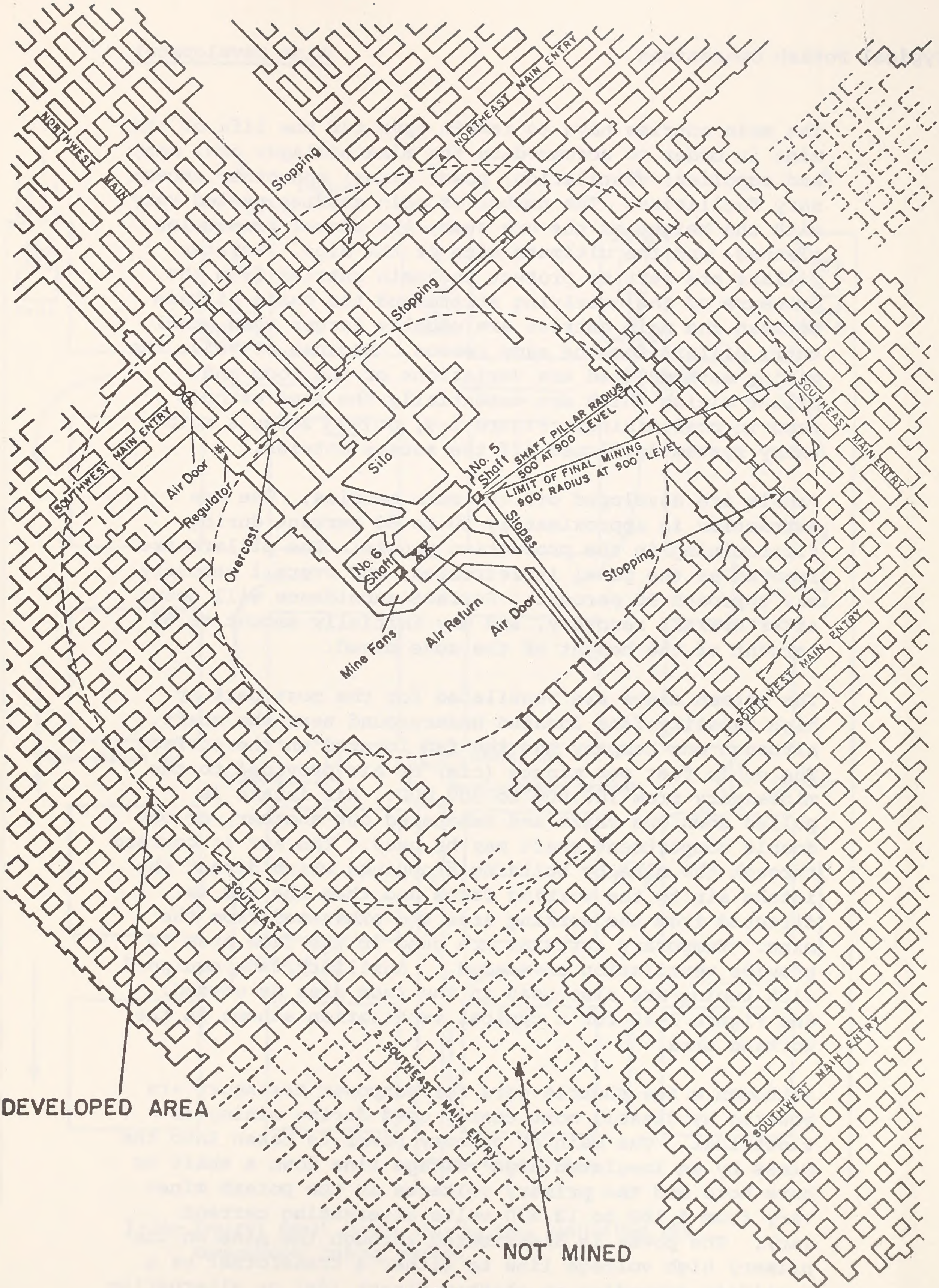


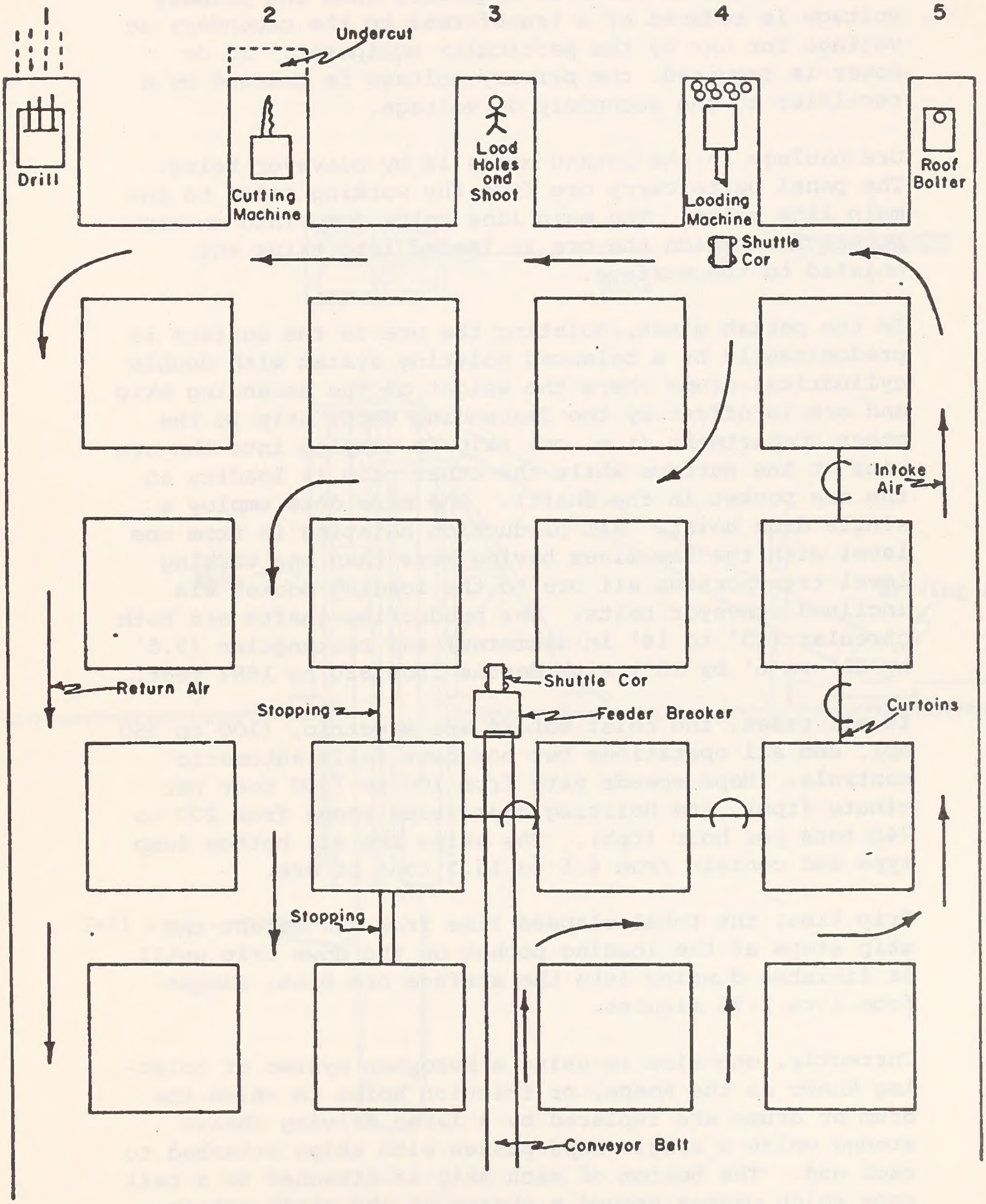
FIGURE I-9 TYPICAL MINE LAYOUT

The main entries have to remain open for the life of the mine in order to accommodate the mine haulage; ore, men, and supplies; ventilation; power lines; and other necessary facilities. The number of main entries needed vary with the height of the ore seam, the annual production planned, and the ultimate size of the mine. Barrier pillars are left to protect the main entries from the pressure of the overlying strata and the chain pillars between the main entries are usually larger than panel entry pillars for the same reason. Because of this, the mining methods used are variations of the room and pillar mining which are essentially the same methods used in coal mining. Figure I-9, p. I-33 shows a main entry system developed off the access entries.

Panels are developed off the main entries. The ore extraction is approximately 50 to 60 percent during first mining in the production panels. The pillars are removed as the panel is retreated, and overall recovery may approach 90 percent. Surface subsidence will occur after overall recovery, and may initially amount to 66 percent of the height of the zone mined.

The potash mines are ventilated for the most part by high capacity fans located underground near the shaft, although one company has the fan located on the surface. The cubic feet per minute (cfm) of air provided to the mines vary from 160,000 to 300,000. Air intake is pulled down one shaft and exhausted out another, or one double compartment shaft may be used. The air is coursed through the mine by building stoppings which direct the intake air to the working faces and then the air is directed from the working area and exhausted from the mine. Temporary curtains are used in the face area to provide ventilation as needed. Auxiliary fans equipped with tubing are also used in the face area as needed. See Figure I-10 for a typical ventilation scheme in the working area.

Although a few shuttle cars for manpower transport are powered by diesel, most energy used during mining is electrical. The main or primary power is taken into the mines by an insulated high voltage line down a shaft or bore hole and the primary voltages in the potash mines vary from 4,160 to 12,470 volts alternating current (ac). The power is distributed through the mine on the primary high voltage line to either a transformer or a rectifier depending on whether direct (dc) or alternating



I-10—Typical panel layout showing face ventilation and conventional mining method.

current is to be used. Some equipment requires ac and others dc. If ac power is required, then the primary voltage is reduced by a transformer to the secondary ac voltage for use by the particular equipment. If dc power is required, the primary voltage is changed by a rectifier to the secondary dc voltage.

Ore haulage in the potash mines is by conveyor belts. The panel belts carry ore from the working faces to the main line belts. The main line belts dump into an ore pocket from which the ore is loaded into skips and hoisted to the surface.

In the potash mines, hoisting the ore to the surface is predominantly by a balanced hoisting system with double cylindrical drums where the weight of the ascending skip and ore is offset by the descending empty skip in the other compartment (i.e. one skip is dumping into the ore bins at the surface while the other skip is loading at the ore pocket in the shaft). One mine does employ a single drum hoist. All production hoisting is from one level with the few mines having more than one working level transporting all ore to the loading pocket via inclined conveyor belts. The production shafts are both circular (15' to 14' in diameter) and rectangular (5.5' by 21' to 6' by 18') with depths from 820 to 1687 feet.

In all cases, the hoist motors are electric, (100 to 350 hp), and all operations but one have fully automatic controls. Rope speeds vary from 100 to 1500 feet per minute (fpm), and hoisting capacities range from 200 to 740 tons per hour (tph). The skips are all bottom dump type and contain from 4.5 to 15.5 tons of ore.

Trip time, the total elapsed time from the moment the skip stops at the loading pocket on the down trip until it finishes dumping into the surface ore bins, ranges from 1 to 2.75 minutes.

Currently, one mine is using a European system of hoisting known as the Koepe, or friction hoist in which the drum or drums are replaced by a large driving sheave around which a single rope passes with skips attached to each end. The bottom of each skip is attached to a tail rope which passes around a sheave at the shaft bottom. Figure I-11 is a simplified diagram of the Koepe Hoist

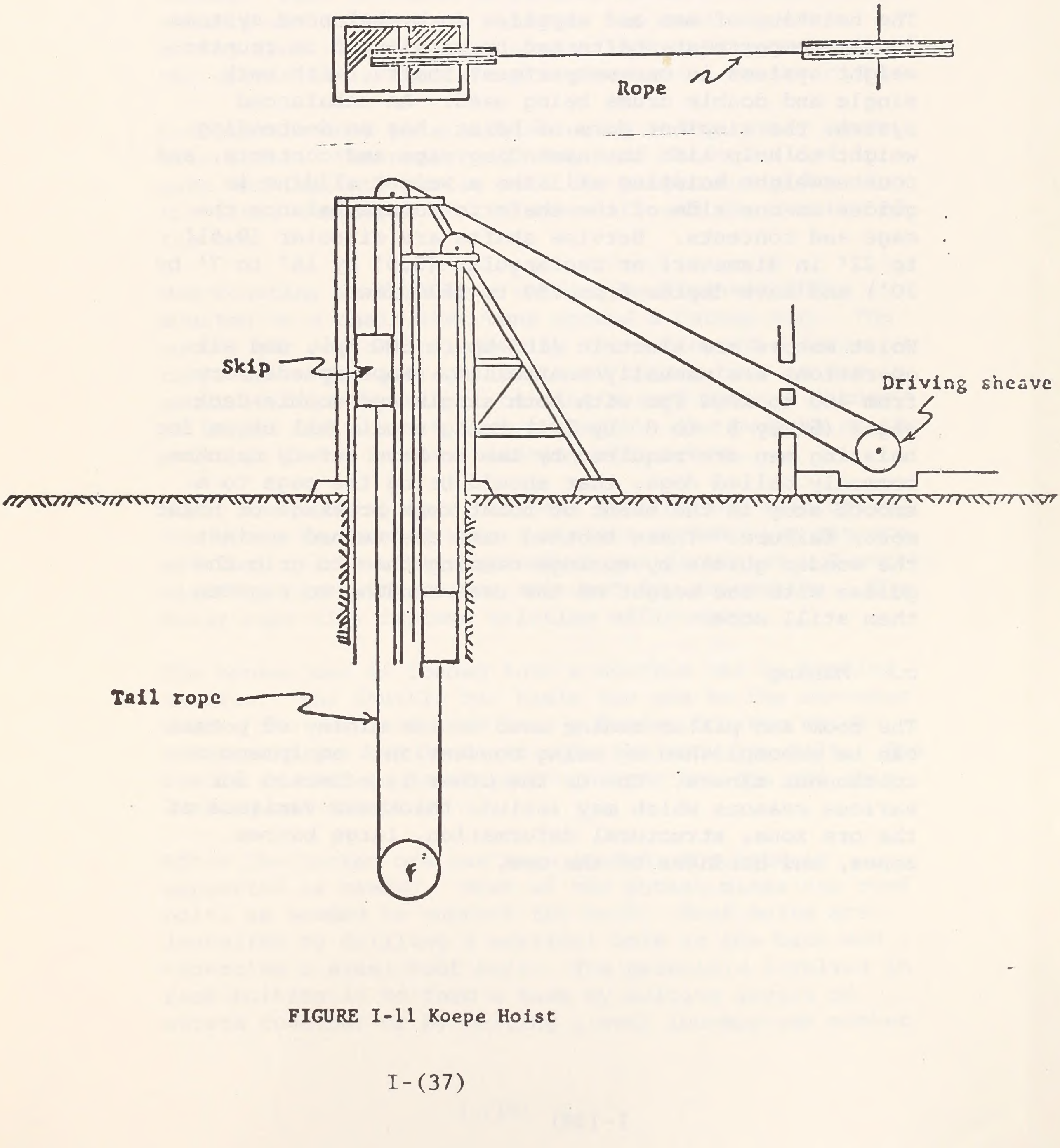


FIGURE I-11 Koepe Hoist

showing the use of only one rope at both top and bottom; the hoist presently in use has 6 ropes at the top and 3 at the bottom.

This system is also electric (1600 hp) with fully automatic controls and has a rope speed of 1750 fpm and a hoisting capacity of 475 tph. Bottom dump skips holding 12 tons have a trip time of 1.5 minutes.

The hoisting of men and supplies is by balanced systems in two-compartment shafts and by unbalanced or counterweight systems in one-compartment shafts, with both single and double drums being used. An unbalanced system, the simplest form of hoist, has no descending weight to help lift the ascending cage and contents, and counterweight hoisting utilizes a weight sliding in guides on one side of the shaft to counterbalance the cage and contents. Service shafts are circular (8.51' to 22' in diameter) or rectangular (5.5' by 16' to 7' by 20') and have depths from 750 to 1630 feet.

Hoist motors are electric (100 hp to 600 hp), and all operations are manually controlled. Rope speeds vary from 400 to 1000 fpm with both single and double-deck cages (5' by 5' to 8' by 10') being used. All cages for hoisting men are required by law to have safety catches, commonly called dogs, that should bring the cage to a smooth stop in the event of hoist rope breakage or hoist motor failure. These toothed cams are turned against the wooden guides by springs causing them to grip the guides with the weight of the cage tending to tighten them still more.

c. Mining

The room and pillar mining used in the mining of potash can be accomplished by using conventional equipment or continuous miners. One or the other is selected for various reasons which may include thickness variance of the ore zone, structural deformation, large barren zones, and hardness of the ore.

(1) Conventional Mining

A conventional mining panel is shown in Figure I-10, p. I-35. Only five working places are shown in the figure although several more may be used for various reasons. The different phases of the operation follow each other and are worked on a repeating cycle. The ore is drilled, blasted, loaded, and the back (roof) is supported as needed. Each of these operations is carried out simultaneously and follow each other in the same sequence, moving from right to left across the working area with the operation in the left place returning to the right.

Drilling is done by a machine using a dry rotary electric drill. The number and depth of holes drilled in each working face varies with the height and width of the face, the depth of the undercut, and the density of the ore.

Undercutting is done by a cutting machine with bits mounted on a chain that runs around a cutter bar. The cutter bar and chain resembles the action of a large chain saw. The average length of cutter bars in use is about 10 feet capable of cutting a kerf about 6 inches in height and about 9 feet in depth. The purpose of the undercut is to improve blasting efficiency.

After the working face has been drilled and undercut, the holes are loaded with a mixture of ammonium nitrate and fuel oil or other explosives and detonated. Electric blasting caps with delays are used for detonation. The delay caps also improve balsting efficiency.

The broken ore is loaded into a shuttle car by loading machine. The shuttle car hauls the ore to the conveyor belt. The ore is dumped into a feeder breaker which breaks the ore and loads it onto the conveyor belt. The ore is crushed to facilitate conveyor haulage and skip loading and hoisting.

After the broken ore has been loaded, the back is supported as needed. Most of the potash mines use roof bolts as needed to support the back. Roof bolts are installed by drilling a vertical hole in the back and inserting a steel roof bolt. The principle involved in roof bolting is to form a beam by bolting layers of strata together or by bolting a weak incompetent member of the overlying strata to a strong competent member directly above. The length of roof bolts used vary from 2 to 8 feet. Timbers and timber cribs are also used as needed to support the back.

(2) Continuous Mining

The continuous mining used in potash mining accomplishes essentially the same thing as conventional mining. The continuous miner takes the place of the drill, the undercutting machines, blasting and the loading machine. Everything remains the same except the continuous miner cuts the ore and loads it into a shuttle car. In continuous mining there is no need to blast the ore.

d. Refining

All the Carlsbad area refineries process sylvite ore, containing about 20 to 35 percent sylvite, equivalent to 13 to 22 percent potassium oxide, and contaminated with 60 to 75 percent halite, 1 to 7 percent clay and up to 5 percent other salts. Additionally, langbeinite-halite ore containing about 50 percent langbeinite equivalent to about 11 percent potassium oxide is processed by two of the refineries(Duval and IMC), and mixed langbeinite-sylvite halite ore is processed by one refinery (IMC). The principal products are sized fractions of (1) potassium chloride containing 60 to 62 percent potassium oxide equivalent; (2) potassium sulfate containing 50 percent potassium oxide equivalent; and (3) langbeinite containing the equivalent of 22 percent potassium oxide, 18 percent magnesium oxide, and 22 percent sulfur. Overall recovery of potash from the refinery feed ranges from 65 to 85 percent.

Large deposits of polyhalite also occur in the Carlsbad area. These are not processed currently because they offer a lower percentage of recoverable potash and appear to be expensive to process by known procedures. (See Apppendix A-15 for discussion of experimental polyhalite refining.)

(1) Sylvite Process

Sylvite ore is usually processed by selective flotation of potassium chloride. Fine potassium chloride is separated from the feed or products, and reprocessed by compaction, recrystallization, and dissolution to make refinery brine, or reaction with langbeinite to make potassium sulfate. Equipment types and process details differ among the several refineries but the flowsheet in Figure I-12, generally depicts current operating practice. Individual operations numbered to correspond with the flowsheet steps are summarized as follows:

Step 1, Dry Crush and Size - The ores initially are dry crushed in hammer mills and screened to make feed ranging in size from minus 4 mesh to minus 10 mesh (0.185 to 0.065 inches) for wet processing. Sprinkling the ore with a small amount of water or brine helps allay dust in the crushing and grinding circuit. Also cyclone dust collectors are used to advantage.

Setp 2, Scrub and Deslime - Crushed and sized ore is slurried in recycled brine (about 11 percent potassium chloride and 22 percent sodium chloride solution), then scrubbed to loosen adhering clay. Next the ore particles are sized and the clay removed by elutriation (desliming) using combinations of hydroclones, screens, classifiers, and hydroseparators.

Step 3, Flotation - Separation of sylvite from halite and residual clay by flotation is based on the selective filming of sylvite particles with an amine reagent collector that is water repellant and air avid. Separation takes place in a flowing slurry of reagent treated brine and salts (flotation pulp) into which air bubbles are dispersed. The bubbles attach themselves to the amine filmed sylvite particles and balloon-like, lift them to the surface of the pulp. A froth of the sylvite coated bubbles accumulates on the surface of the pulp and is skimmed into launders as a sylvite concentrate. Residual pulp containing the halite tailings flows from the bottom of the flotation cells.

The amine ordinarily used is a primary amine containing 16 to 18 carbon molecules prepared from tallow fatty acids. It is a water insoluble, waxy solid. The amine usually is one-third to one-half neutralized with acetic or hydrochloric acid for use in potash flotation, and is made up, stored and fed as a 2.5 to 5 percent dispersion in water. About 0.1 to 0.3 pound of amine is used per ton of ore.

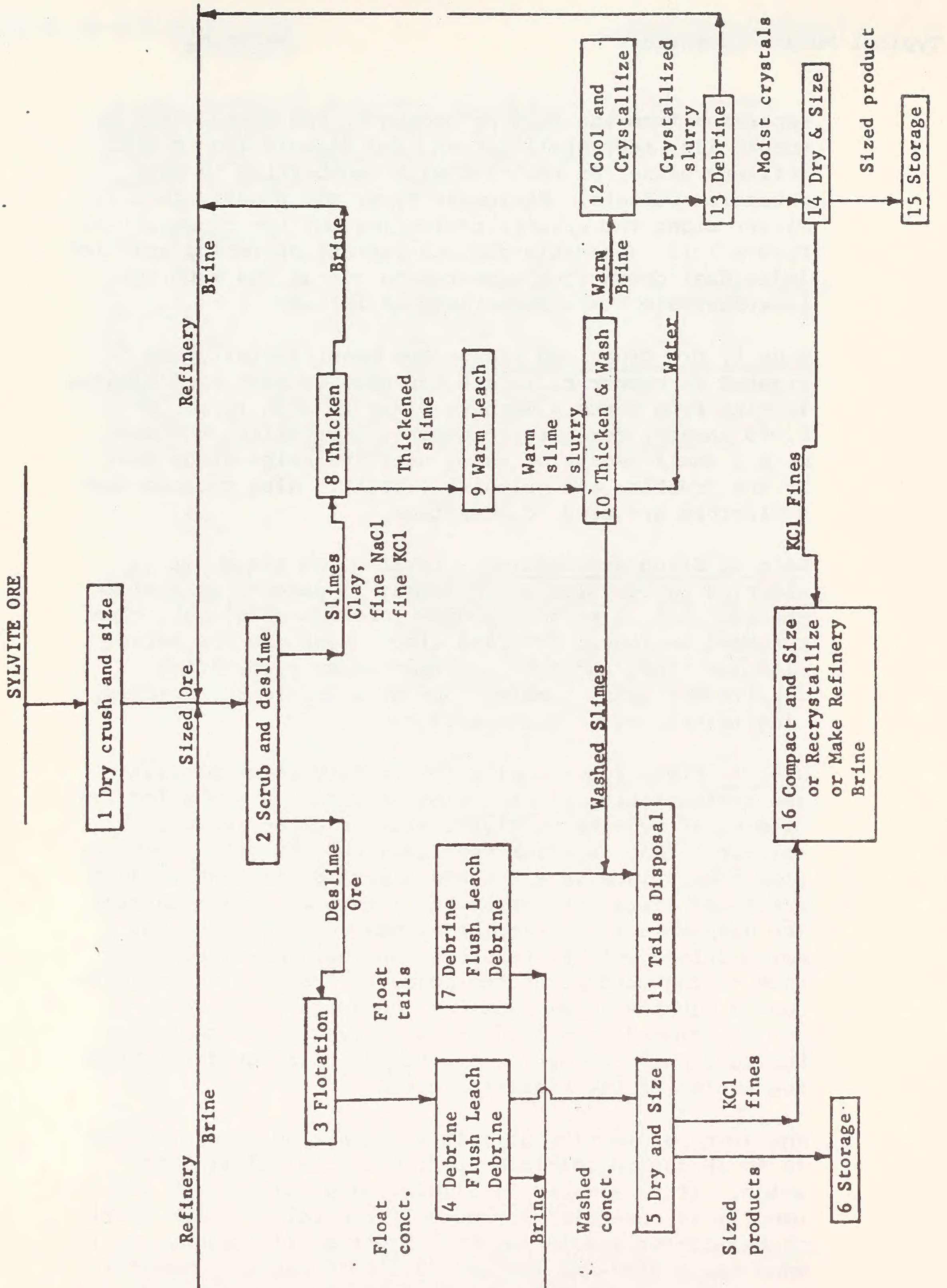


FIGURE I-12 Sylvite Ore Flowsheet

Other reagents that are commonly used are a depressant or blocking agent (starch) for the clay slimes, a frother to stabilize the air bubbles and fuel oil that assists both the amine collector and the frother in their respective roles. About 0.1 to 0.2 pound of starch, 0 to 1.5 pounds, fuel oil, and 0.05 to 0.1 pound of frother are used per ton of mill feed. Coarse and fine sylvite fractions are separately floated and starch is added only to the fine flotation circuit that contains clay slimes. Fuel oil usually is added only to the coarse flotation circuit.

Reagents are added to conditioners, usually horizontal rotary drums with a corrugated surface, in advance of flotation. Both pneumatic and induced air (mechanical) cells are used for flotation. The froth (rougher concentrate) from the first bank of flotation cells is refloated (cleaned) to drop out entrained halite and clay. Flotation reagents, except for the frother, are absorbed on and retained by the clay and concentrate.

Step 4, Debrine Flotation Concentrate - Flash Leach-Debrine - The cleaned concentrate, containing about 95 percent sylvite (60 percent potassium oxide), is separated from the brine on screens or in hydroclones and briefly leached with potassium chloride brine to dissolve most of the remaining halite. Leached flotation concentrate containing over 98 percent sylvite (62 percent potassium oxide) then is separated from the brine by centrifuging. Brines from this step join the refinery brine for recycling.

Step 5, Dry, Size, and Store the Flotation Concentrate - The moist concentrate is dried by heating to between 350° and 450°F in a direct fired rotary kiln using natural gas for fuel. Usually the concentrate and combustion gases travel through the kiln in the same direction (concurrent firing), but countercurrently fired dryers also are used.

The potassium chloride may reach a higher temperature in countercurrent firing and residual flotation oils are more likely to burn away. This may require the addition of oil to the dried product to lessen caking and dusting during storage and handling. Mechanical rappers are used on the kiln shell to prevent caking of the product on the interior of the shell. Dryer stack gases have not been well characterized. The gas contains moisture, combustion products, fine sylvite, and possibly a trace of hydrogen chloride that forms by hydrolysis of magnesium chloride that may be present in the feed to dryer.

The product from the driers is sized pneumatically on screens and material finer than about 65 mesh is removed for reprocessing. Three grain sizes of potassium chloride ordinarily are marketed. In the order of decreasing value, these are granular (minus 8 to plus 20 mesh), coarse (minus 10 to plus 28 mesh), and a standard (minus 28 to plus 150 mesh). Storage buildings that can hold several months' production protect the finished product until shipped to market.

Step 6, Debrine Flotation Tailings-Warm Leach-Debrine - Flotation tailings containing halite and clay with a small percentage of sylvite is separated from the brine on screens or in hydroclones and leached briefly in warm brine to selectively dissolve unfloated sylvite. Cool brine returns to the refinery brine circuit, while the warm brine may be cooled and crystallized for recovery of potassium chloride.

Steps 7, 8, and 9,- Thicken, Leach, and Wash Slimes - Brine from the desliming circuit contains clay and fine particles of sylvite and halite. Depending on how much clay and fine sylvite is present the following alternative systems are used for recovery. (1) Slime slurry is thickened to recover brine for refinery use and the thickener underflow which contains brine, clay and fine particles of sylvite and halite is discarded. (2) Slimes are thickened and washed by countercurrent decantation in a series of thickeners using a fresh water wash to remove adhering brine and sylvite and halite particles are dissolved. (3) Slime slurry is warmed and thickened as in option No. 1 and is then leached in warm brine from Step 6 to selectively dissolve sylvite. Slime residue is thickened, washed, and discarded. Polyacrylamide flocculants ordinarily are used to accelerate the settling rate of the clay in the thickeners. About 0.01 to 0.10 pound of flocculant is used per ton of mill feed and as much as two-thirds of the clay ordinarily is removed in the desliming circuit.

Step 10, Tailings Disposal - The leached flotation tailings are slurried in recycled brine from the tailings pond, in brackish water, or in the slime thickener underflow slurry, and pumped to the disposal site. Coarse salts, admixed with clay, settle rapidly at the tailings line discharge and may form high mounds of salt and clay. Dry mounds have a coherent and dust-free surface. Fine salt and clay are settled in unlined tailings ponds. Brine levels in the ponds are controlled by evaporation with or without recycling the brine for slurrying the refinery tailings. Based on water balances and estimates of evaporation, substantial seepage of brine may occur. The extent of the seepage and the path it follows probably varies with the clay content of the tailings slurry and the pond location. Washing of flotation tailings and clay slimes with fresh water to reclaim adhering brine with a high potash content is necessary for maximum potash recovery from the ore. The introduction of such fresh water necessitates subsequent bleeding of water from the refinery circuit to maintain an operable solution balance. Water is removed from the refinery by evaporation in crystallizers, Ozarks, and dryers, and as brine tailings. The latter, in turn, loses water by solar evaporation or dissipates as seepage.

Step 11, Cool and Crystallize Potassium Chloride Rich Brine - Debrine the Crystals - Brines at a temperature of about 150° to 200° F, that have been enriched in potassium chloride by leaching flotation tailings, slimes, or sylvite, ore are cooled to about 80° or 90° F in multi-stage vacuum crystallizers using steam jets for pulling the vacuum. The potassium chloride content of the brine drops from about 19 percent at 200° F to 11 percent at 80° F. Potassium chloride crystals that form may be increased in size by prolonged retention with suitable agitation in the crystallizers. Crystallized potassium chloride is separated from the cool brine in centrifuges and the brine is recycled to the refinery circuit.

Step 12 and 13, Dry, Size, and Store Potassium Chloride Crystals - Reprocess Potassium Chloride Fines - Moist crystals from the centrifuges are dried, sized, and stored, and the fines (minus 65 mesh), along with fines from Step 5 are reprocessed by (1) dissolution to make refinery brine or crystallizer feed brine; (2) reaction with langbeinite to make potassium sulfate; and (3) compaction into "boards" by pressure rolls, followed by fragmentation of the "boards," and sizing of the fragments as in Step 5. Compaction and fragmentation tend to be dusty operations.

(2) Langbeinite Process

Langbeinite ore is composed of roughly equal amounts of langbeinite and halite, with a percent or so of clay and, a few percent other salts. The products are potassium magnesium sulfate and potassium sulfate, the latter derived partly from potassium chloride fines diverted from the sylvite ore process. Figure I-13 is a generalized flowsheet for processing langbeinite ore.

Mixed ore, which is langbeinite ore containing a few percent sylvite, is processed using a similar flowsheet but including preconcentration of plus 20 mesh ore by magnetite heavy media. The heaviest fraction--langbeinite is leached to remove the NaCl. The medium weight fraction, halite, is discarded. Sylvite, the lightest fraction, is floated to make a potassium chloride concentrate, as is also the minus 20 mesh ore. After floating sylvite from the minus 20 mesh ore, the tailings are debrined, and langbeinite is floated using a fatty acid reagent to make a potassium magnesium sulfate product and halite tailings for discard.

Langbeinite ore processing is based on the relative insolubility of langbeinite as compared to sodium chloride, and on the relatively lower solubility of potassium sulfate, than of potassium chloride and magnesium chloride. Individual operations are numbered to correspond with the flowsheet steps in Figure I-13 as follows:

Step 1, Dry Crush and Size - The ore is crushed in hammer mills to pass 3 or 4 mesh and sized by screening into plus and minus 14 mesh fractions. Langbeinite is harder and more difficult to crush than sylvite. The more friable sylvite tends to concentrate in the crushed ore fines. Cyclone collectors are used for dust control.

Step 2, Leach Sodium Chloride from Plus 14-mesh Ore - Water is used to leach sodium chloride from the coarse langbeinite, resulting in a brine that is about 40 percent saturated in sodium chloride. The leach slurry is debrined.

Step 3, Leach Sodium Chloride from Minus-14 Mesh Ore - Weak brine from step 2 is used in leaching sodium chloride from the fine langbeinite, resulting in a brine that is about 90 percent saturated in sodium chloride. The leach slurry is debrined and the brine discarded.

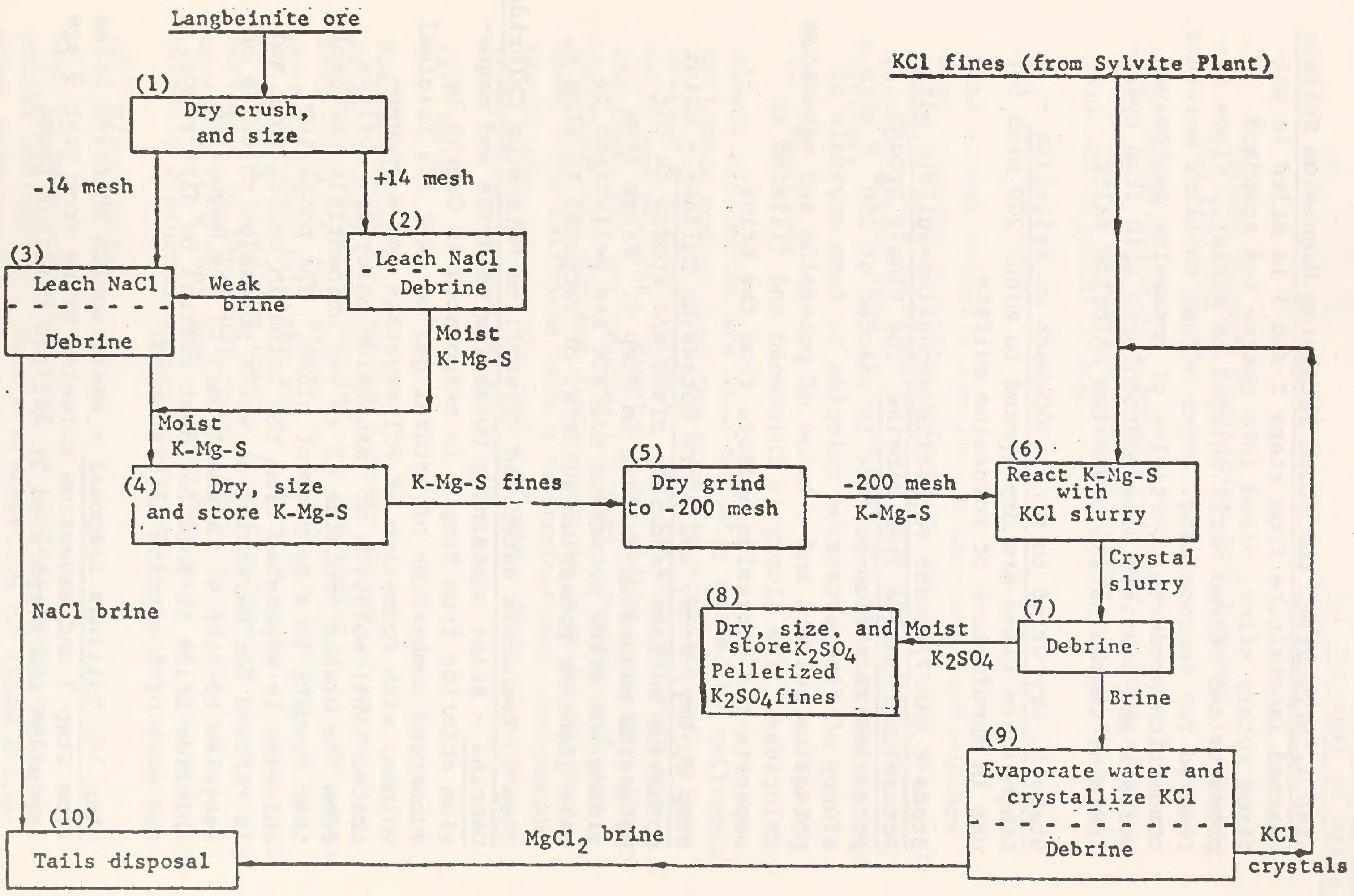


FIGURE I-13 Langbeinite Ore Flowsheet

Step 4, Dry, Size, and Store Potassium Magnesium Sulfate Leached langbeinite from steps 2 and 3 is dried in gas-fired rotary kilns, sized into coarse and standard products and stored until shipped to market. Fines are removed for reprocessing. Dryer offgas contains moisture, combustion products, particles of potassium magnesium sulfate and possibly some hydrochloric acid from hydrolysis of contaminating magnesium chloride salts.

Steps 5, Dry Grind to Minus 200-Mesh or Pelletize - Langbeinite fines are dry ground to minus 200 mesh for use in manufacture of potassium sulfate.

Steps 6 and 7, React Potassium-Magnesium-Sulfate with Potassium Chloride Then Debrine The finely ground potassium-magnesium-sulfate is reacted at 160° F with a slurry of fine potassium chloride to form crystals of potassium sulfate and a brine of potassium and magnesium chlorides. The slurry is thickened and filtered to separate the potassium sulfate from the brine.

Step 8, Dry, Size, and Store Potassium Sulfate - Moist potassium sulfate is dried, sized and stored as for potassium magnesium sulfate in Step 4. Fines from sizing the dried potassium sulfate are pelletized to make granular potassium sulfate, or recycled to Step 6.

Step 9, Evaporate Water and Crystallize Potassium Chloride; Debrine - Brine containing potassium chloride and magnesium chloride from Step 7 is evaporated in Ozarks by submerged combustion of natural gas to half its original volume, with formation of KCl crystals and a concentrated (16%) solution of magnesium chloride. Offgas from the Ozarks contains an as yet unidentified aerosol that results in a persistent plume. The potassium chloride is separated from the brine in centrifuges and is refined for marketing as white potassium chloride or recycled to Step 6. A small part of the magnesium chloride brine is sold for dust control on dirt roads, but most of the brine is discarded.

Step 10, Tailings Disposal - Waste sodium chloride brine from Step 3 and magnesium chloride brine from Step 9 are impounded and evaporated in unlined tailings ponds.

e. Typical Support Facilities and Disposal of Waste and Tailings

The installation of a potash refinery on federal lands involves the following typical support facilities and tailings disposal areas.

(1) Road Access

Road access normally involves a two-lane hard surface road from the existing highway to the refinery site. If the mine site is situated away from the potash refinery, another access road is necessary for hauling ore to the refinery.

(2) Railroads

Potash refineries are also normally served by railroads. Railroads coming into the area are standard gauge, requiring a roadbed (crown). The maximum grade is normally one percent. Right-of-way widths vary from 100 to 150 feet, but are usually 100 feet. During railroad construction, surface disturbance is usually 100 feet wide. The railroads have a communications line beside the tracks, within the right-of-way. This is an above ground line, supported by poles.

(3) Water

Potash refineries require a great amount of water (the existing potash refineries use approximately 12,000 acre feet annually) and since the supply is limited, water must be piped into the area. This is normally done with 10-14 inch pipelines coming from the Caprock area to the northeast of the study area. These lines are normally buried 2 to 4 feet deep. A surface area 40 feet wide is normally disturbed during construction of the pipeline.

(4) Electricity

High voltage electric power is another requirement of potash refineries. On the average, 69 KV lines bring power from the existing powerline networks to the refinery site, where a small substation is installed to step the voltage down to 4,100 volts. The installation of this powerline involves a right-of-way width of 40-60 feet, as determined by BLM. Actual surface disturbance width averages 20 feet.

(5) Gas

All potash refineries require natural gas service, which is provided through pipelines. These pipelines have a diameter of 4 inches and are normally buried 2 feet below the ground surface. Currently, the installation of these lines involves a right-of-way width of about 50 feet. Most existing rights-of-way widths are only 20 feet because they were obtained years ago when narrower widths were acceptable. Surface disturbance during gasline construction is about 40 feet.

(6) Waste Disposal

All potash operators have the problem of sewage and solid waste disposal. Each refinery normally has a septic tank system within the plant site for handling sewage. Each plant also has a dump site for the disposal of solid wastes. Such a site is normally only about 1-2 acres in size.

(7) Tailings Disposal

Tailings disposal involves disposal of solid salts and brines. The solid salts are placed on tailings piles and the brine liquids are dumped into ponds. Together the area of the salt pile and the brine ponds for a typical potash refinery encompasses about 575 acres. The seven existing plants have tailings disposal areas ranging from approximatly 80 to 1150 acres.

f. Lease Abandonment

Lease abandonment is the final phase of a typical potash operation. This involves a company leaving a particular site after completing exploration, mining, or refining operations.

If no suitable ore deposit is found, abandonment involves only reclamation of the drill pads, drill holes, and access roads which has been described earlier. Abandonment of a site having a refinery and ore hoisting equipment, involves dismantling and removal of the refinery and hoisting apparatus. Waste debris is buried in authorized sanitary land fills or hauled away. The site, exclusive of the salt tailings pile and brine ponds, may be scarified if on-site conditions warrant. Access roads, if no longer needed for another use, may be scarified and allowed to revegetate naturally.

Abandonment of a mine shaft is much more complicated. In January 1972, the Mining Branch of Geological Survey, United States Department of the Interior, requested the seven companies which comprise the potash industry of southeastern New Mexico to conduct a study and make recommendations related to the ultimate disposition of abandoned mine shafts previously employed in underground mining of potash.

At the present time there are 25 vertical mine shafts which have been sunk into the Permian salt and potash horizons. All are in the study area. Most of the shafts are still in use and some will continue to function for several decades. A few of the shafts are no longer in active service as a result of the completion of mining in the potash ore bodies. One shaft was sunk by the Atomic Energy Commission for access to the Gnome Project nuclear detonation tests, and to date is the only shaft which has been abandoned and filled.

As discussed earlier, the mine shafts vary widely in size, configuration, and depth. The vertical shafts which are no longer in active service continue to be maintained pending final disposition of the mines they served, since they tend to deteriorate along the walls, linings, guides and dividers, without periodic attention.

Before a final determination of the method or methods of abandoning a shaft or mine is made, the uses to which it may be put after fulfilling its original functions should be evaluated.

Those operators possessing shafts into mines which have been exhausted or close to exhaustion, have at various times been approached with proposals from industrial and governmental groups, having a wide array of possible alternate uses. Obviously some of the uses would be applicable only to particular mines, while certain others could not be initiated until all underground mining in a district reached completion. A brief overview of the major proposals and other possible alternate uses is summarized below:

(a) The storage of certain types of volatile or toxic chemicals.

(b) The storage of radioactive waste products. This has received consideration by the Atomic Energy Commission, although their feasibility work was concentrated on possible storage in an undisturbed area of the Salado Salt, some distance form existing mining properties. The use of abandoned potash mines for nuclear waste would, if feasible, probably be limited to "low level" radiation products.

(c) The warehousing of a wide variety of general supplies, valuable records, or defense-related strategic materials.

(d) The solution mining of residual potash ore remaining in pillars, or in seams too thin for conventional mining. This mining method, currently being successfully utilized in a former conventional mine in Moab, Utah, would obviously not be practical while known nearby mines remained in use.

(e) The establishing of underground personnel shelters for defense purposes.

(f) Access to lower grade potash zones or other evaporite minerals not presently considered commercial.

(g) The use of underground voids as storage for high pressure air for peak-shaving energy generation purposes. This proposal is currently under evaluation by utilities as a possible means of reducing energy consumption by leveling the output of generating units.

(h) Natural gas or liquid petroleum gas storage. This is another use which would necessarily have to await the abandonment of all underground activity in other mines in the area.

Other proposals may be developed which cannot now be foreseen. Basically there are many possibilities for deep seated, relatively airtight, uniform temperature underground voids which may only be feasible if they do not require a large amount of expensive excavation to prepare.

There had been very little material published on the subject of abandoning mine shafts in the United States, and at this time there are no established procedures, guidelines, practices or regulations which have been used in the various mining districts of the United States. While there have been certain procedures adapted in some areas of Europe, particularly Germany, they apparently are limited to specialized conditions having no applicability to the mines of southeastern New Mexico.

The 1972 industry study considered two primary questions in developing recommendations for shaft abandonment. They are: 1) potential water or brine invasion, and 2) effects of potential shaft subsidence deformation. Recommendations of the study are as follows:

(a) Restrict the rate of water flow into the mine by filling the shaft with sand and rock (non-soluble materials), to a depth above the most shallow water producing formation. This would restrict water flow and protect the abandoned shaft from collapsing.

(b) All shafts at the time of abandonment should be adequately covered at the surface to prevent injury to people, livestock and wildlife. The cover should be a substantial structure, securely anchored to the shaft collar and capable of supporting a 5 ton load. The cover should be vented with a steel pipe arranged to prevent an influx of rain or surface moisture into the shaft. A steel pipe should be set in concrete adjacent to the shaft, with a brass plate noting the survey location of the shaft and its designation. This procedure should satisfy the needs, provide protection and avoid future damage to the general public, other land users, and the natural resources of the area. These recommendations have not been utilized because no potash shafts have been abandoned to date.

In summary, the above are some of the possible alternatives and recommendations available to the potash industry and regulatory agencies when the time comes that abandonment of specific shafts will be undertaken.

2. Anticipated Experimental Operations

The subjects of polyhalite and solution mining are of considerable interest to the potash industry. In view of the industry interest, it is anticipated that there will be some experimental attempts at polyhalite refining and solution mining of potash ores during the 20 year time period covered by this analysis. Appendix A-15 describes the general principles upon which the experimental operations may be based.

B. Interrelationships with Other policies, Plans, and Projects

The major portion of the potash produced in New Mexico is used in fertilizer production which will greatly enhance the world's food production.

At the recent World Food Conference held in Rome, Italy in November 1974, representatives of one hundred and thirty nations emphasized that one of the most important issues facing mankind is world hunger.

World food shortages have intensified the interest in fertilizers as a means of increasing crop yields and thereby increasing total food production. One positive action taken at the Conference was the decision to devise a systematic approach to worldwide fertilizer production and distribution.

Based on 1972/73 figures, the United States ranked fifth as a producer and exporter, but first as a consumer and importer of potash. The USSR was the leading producer and ranked second as a consumer and third as an exporter. Of the major potash producers, Canada, West Germany, East Germany and Israel exported more K_2O than was used at home. The top 10 importers of potash are the United States, Poland, Czechoslovakia, Japan, United Kingdom, Brazil, Hungary, Belgium, India, and the Netherlands. The first 5 of these are among the top 10 users of K_2O.

During the fertilizer year ending June 30, 1974, the United States experienced a sharp increase in imports and a slight increase in exports of potassium. Canada supplied the major share of the United States potash imports. Imports of 4 million tons of K_2O from Canada supplied the equivalent of about 75 percent of the United States consumption, compared with 66 percent in 1972/1973. The United States took about 71 percent of Canada's 1973/1974 production. In spite of increased production in 1973/1974, Canada's closing inventory last summer was considerably lower than in previous years.

If potash use continues to grow at the current rate, the world supply will come from expanded production in North America and by the large scale incursion into the western markets of potash from the Soviet Union. In 1973, the USSR shipped 705,000 tons of K_2O to the West out of a total production of 2.19 million tons and is expected to achieve a substantially higher percentage in 1974, as a result of new business secured in Europe, Brazil and the United States.

The Canadian and United States export market is expected to continue strong with a projected increase from 2.4 million tons of K_2O in 1974 to 2.5 million tons in 1975.

Potash demand in the remaining countries of the free world is expected to increase from 16.6 million tons of K_2O in 1973/1974 to 17.4 million tons in 1974/1975. Potash demands in the communist countries, which totaled 7.4 million tons of K_2O in 1973/1974, is expected to increase to 7.8 million tons in 1974/1975.

World potash supplies will increase about 5 percent in 1974/1975; however, this will not be enough to meet the record world demand. Reconciliation of the Canadian restraints on production holds the key to bringing the world potash supply and demand into better balance. For detailed potash/fertilizer statistics see Appendix C-34 and C-35.

The local interrelationships between the proposed action and other projects and programs are discussed in Part II, Land Use Compatibility and Suitability, page ___.

C. Federal Roles in Potash Development

1. Department of the Interior

The role of the Department of the Interior is to make potash available to private industry at a fair market value without causing undue waste of other valuable resources. The Department exercises this role through the cooperative efforts of the BLM and the USGS. This cooperation is delineated in Secretarial Order 2948.

a. Bureau of Land Management

BLM's role in potash leasing is to make final determination as to what federal potash deposits are made available to industry through the potash prospecting permit process or the leasing process. As the surface managing agency, BLM has a role to protect the surface resources and to ensure that surface resources are not needlessly wasted or destroyed during potash mining and refining. As the owner of lands adjacent to leases BLM also has the role of granting rights-of-way to provide utility service to facilitate the development of potash leases.

BLM is the land title agency of the federal government, therefore, BLM has the role of maintaining title records for all potash leases and permits.

b. U. S. Geologic^al Survey → Min. Manage. Service → BLM

The USGS role in potash leasing is one of evaluating the land to determine if potash is present and ensuring that the federal government receives fair market value for the public mineral resources. In order to accomplish this, the USGS administers all the operational lease terms and stipulations in all potash permits and leases. The USGS also has the role of collecting the royalties for potash and ensuring that proper mining techniques are used to avoid wasting the potash resources and other mineral resources in the area.

c. NEPA Relationships

Under NEPA both the BLM and the USGS have a role to develop measures to mitigate environmental impacts and determine if an Enviornmental Impact Statement (EIS) is necessary prior to issuing leases or approving development plans. If an EIS is necessary, both agencies cooperate to prepare the document.

d. MESA

The role of the Mine Enforcement and Safety Administration (MESA) is to assure that potash mining and refining operations are conducted so as to maintain safe and healthful conditions.

e. Bureau of Mines

The role of the Bureau of Mines is to compile and publish statistical data on domestic and worldwide potash production and use. The Bureau also conducts research and development to improve the efficiency and safety, and to minimize adverse environmental effects of mining and mineral processing.

2. Other Agencies' Roles

a. Environmental Protection Agency

The role of the Environmental Protection Agency (EPA) is to administer both the Clean Air Act of 1970, as amended, and the Federal Water Pollution Control Act of 1972, as amended.

b. Interstate Commerce Commission

The role of the Interstate Commerce Commission (ICC) is to regulate transportation systems and to establish and maintain freight rates on potash and related articles from the Carlsbad area to destinations in the United States.

D. State and Local Roles in Potash Development

1. State

a. Land Office

The role of the State Land Office is to grant rights-of-way and mineral leases on State lands and to obtain the greatest monetary benefit for the State.

b. Oil Conservation Commission

The role of the Oil Conservation Commission (OCC) is to ensure maximum recovery and minimum waste of oil and gas and potash resources.

c. Environmental Improvement Agency

The role of the New Mexico Environmental Improvement Agency (EIA) is to enforce air quality standards and water quality standards under the New Mexico Air Quality Control Act of 1967, as amended, and the New Mexico Water Quality Standards Act approved August 21, 1969. The EIA has full delegation of authority from the Environmental Protection Agency (EPA) to adminster the water pollution control program and the air quality control program. EIA also has responsibilities and jurisdiction over the production of the finished product under the Occupational Safety and Health Act.

d. State Inspector of Mines

The role of the Inspector of Mines is to ensure safe working conditions for mine employees and to ensure public safety.

e. State Engineer

The role of the State Engineer is to administer laws which regulate use of both surface and ground waters of the state.

f. Public Service Commission

The role of the Public Service Commission (PSC) is to regulate all public utilities in the state under the New Mexico Public Utilities Act. Its jurisdiction extends to rate, safety, and environmental aspects (aesthetics) of powerlines (230+ K.V.), telephone lines, gaslines and attendant facilities in the State.

g. State Tax Commission

The role of the State Tax Commission relating to potash is to evaluate the potash mineral properties based on market value of the output of the property for the prior year, less royalties belonging to the State or the United States.

2. Local Government Roles in Potash Development

a. Planning and Zoning

The roles of counties and municipalities is to regulate land uses by comprehensive planning and zoning. To date neither Lea nor Eddy counties has developed zoning regulations, however there is planning in Lea County and Eddy county is in the process of planning.

b. Taxation

The role of the county assessor is to collect taxes on producing potash properties based on the valuations of the State Tax Commission.

E. Interior Department Procedures in Potash Development

Potash prospecting permits and leases are issued under authority of the Act of February 7, 1927 (44 Stat. 1057; 30 USC 281 et seq.), as amended, and are subject to all reasonable regulations of the Secretrary of the Interior (Title 43 CFR Subpart 3500 - Leasing of Minerals Other than Oil and Gas). The leasing and permit program are carried out through the cooperative efforts of BLM ~~and~~ USGS as established under Secretarial Order 2948.

Permits and leases may be issued for as much as 2,560 acres each, except where the rule of approximation applies. Under this rule, they could be issued for a maximum of 2,579.99 acres. Holdings in leases may not exceed 25,600 acres in one or more mining units. Under certain conditions, a lessee who is at or near his maximum in lease holdings, may obtain up to an additional 2,560 non-chargeable lease acres. Leases and permits may be relinquished.

There are twelve types of potash applications and actions as follows:

1) prospecting permits
2) prospecting permit extensions
3) preference right leases
4) non-competitive leases; chargeable
5) non-competitive leases; non-chargeable (fringe acre)
6) competitive leases (applicants motions)
7) competitive lease sales (Bureau actions)
8) lease readjustments (Bureau actions)
9) lease or permit relinquishments
10) assignments of record title to permits or leases
11) assignments of operating rights (subleases)
12) substitution of sureties on permit or lease bonds

A detailed description of the processing of prospecting permits follows. Figure I-14 is a flowsheet, in the back pocket of this report, showing the procedures used for administratively processing prospecting permits, competitive leases, non-competitive leases, and lease readjustments. Table I-3 shows the different information BLM requests from the USGS in processing the various actions. Table I-4 shows the rights which are granted by the government and the rights which are retained by the government when approving the various actions.

TABLE I-3

INFORMATION REQUESTED FROM THE USGS BY THE BLM IN PROCESSING POTASH APPLICATIONS

Application	Determinations Requested from USGS by BLM
1. Prospecting permits	Reports prospecting and drilling requirements and that prospecting is necessary to determine if a potash deposit exists in commercial quantities.
2. Prospecting permit extensions	Reports whether the permittee has conducted the necessary prospecting or related activities, thus entitling the permittee to a two-year extension.
3. Preference right leases	Reports suggested rents, royalties, bonding, production and/or drilling requirements. Includes statement as to whether a valid, commercial discovery has been made on any part or all of the permitted land.
4. Non-competitive leases; chargeable	Reports suggested rents, royalties, bonding, production and/or drilling requirements. Includes statement that application covers land which can not be mined as an independent unit.
5. Non-competive leases; non-chargeable; (fringe acreage)	Reports suggested rents, royalties, bonding, production and/or drilling requirements. Includes statement that application covers land which can not be mined as an independent unit.

TABLE I-3 CONTINUED

Applications	Determinations Requested From USGS by BLM
6. Competitive leases	Reports suggested rents, royalties, bonding, production and/or drilling requirements. Includes statement that minimum acceptable bid will be discussed with BLM before and after sale. States leasing units which will be offered for bid.
7. Competitive lease sales (Bureau motions)	Reports suggested rents, royalties, bonding, production, and/or drilling requirements. Includes statement that minimum acceptable bid will be discussed with BLM before and after sale. States leasing units which will be offered for bid.
8. Lease readjustments	Reports suggested rents, royalties, bonding, production and/or drilling requirements.
9. Lease or permit relinquishments	Reports 1) that relinquishment will not affect the Government's interests, 2) whether there is any money owed to the Unites States, 3) if property has been properly conditioned for abandonment, 4) if bond can be released.
10. Assignments of record title to permits or leases	Reports status of account, condition of property. Includes statement as to whether assigner's bond can be released.

TABLE I-3 CONTINUED

Applications	Determinations Requested From USGS by BLM
11. Substitution of sureties on permit of lease bonds	Reports status of account, condition of property. Includes statement as to whether assignor's bond can be released.
12. Assignments of operating rights (Subleases)	Reports whether any liability has occured under the bond being replaced or not.

Table I-4

RIGHTS GRANTED AND RETAINED IN VARIOUS POTASH ACTIONS

APPLICATION	RIGHTS GRANTED	RIGHT RETAINED
1. Prospecting Permits	1. Exclusive right to prospect on and explore lands involved to determine existence, workability, and commercial value of potash deposits.	1. Right to issue other permits for the same land for the deposits of other minerals.
	2. Right to extend permit if proper conditions are met.	2. Right to terminate the permit automatically for non-payment of rental as prescribed.
	3. Right to surrender all or part of prospecting permit subject to acceptance by BLM.	3. Right to prescribe steps for restoration of lands.
	4. Right to assign permit or interest in it subject to approval by BLM.	
	5. Right to preference right lease if permittee discovers valuable potash deposits in lands involved.	
2. Prospecting Permit Extensions	Same as Prospecting Permit above excluding 2. right to extend permit.	Same as Prospecting Permit above.

Table I-4 continued

3. Preference Right Leases	1. Exclusive right to mine and dispose of all the potassium associated deposits in leased lands.	1. Right to terminate new leases for non-payment of rental as prescribed. First 5 years unless production is attained during that 5 years.
	2. Right to construct and maintain all structures necessary for the mining processing and removal of the deposits for 20 years and so long thereafter as the lessee complies with lease stipulations.	2. Right to examine plats showing development on leased land.
	3. Right to surrender all or part of lease subject to acceptance by BLM.	3. Right to request be furnished stockholders reports and other reports regarding financial status of operation.
	4. Right to assign lease subject to approval.	4. Right to examine leased premises, operations, works, machinery, books, records, etc., at all reasonable times.
		5. Right to permit through the land leased as may be necessary or appropriate to the same or other land usage as authorized by law.
		6. Right to lease, sell or otherwise dispose of the surface of leased lands as prescribed by law as long as surface is not necessary for mining, or to dispose of any resource in such lands that will not unreasonably interfere with the operations under the lease.

Table I-4 continued

		7. Right to prevent monoploy and preserve fair prices. 8. Right to reasonably readjust lease terms every 20 years. 9. Right to waive any breach of conditions except the breach of such conditions as are required by the Act. (44 Stat. 1057;30 USC 281 et. seq.) 10. By stipulation, the right to prescribe steps for restoration of lands. 11. By stipulation, the right to make applicable in its entirety 43 CFR part 23. 12. Right to take over property left upon lease termination as prescribed.
4. Non-competitive leases (Chargeable)	Same as 3. Preference Right lease above.	Same as 3. Preference Right lease above.
5. Non-competitive Leases (not chargeable)	Same as 3. Preference Right lease above.	Same as 3. Preference Right lease above.
6. Competitive Leases	Same as 3. Preference Right lease above	Same as 3. Preference Right lease above.

Table I-4 continued

7.	Competitive Leases	Same as 3. Preference Right lease above	Same as 3. Preference Right lease above.
8.	Lease Readjustments	Same as 3. Preference Right lease above	Same as 3. Preference Right lease above
9.	Relinquishment of lease or permit.	Releases lessee or permittee from future liability.	May require rehabilitation of the surface beyond the date the relinquishment is accepted.
10.	Assignments of record title to permits or leases.	Same rights acquired by original lessee.	Same rights retained in original lease or permit.
11.	Assignments of operating rights (subleases)	Restricted rights. Lessee's rights are paramount.	Lessee or permittee is still held responsible and government retains same rights.
12.	Substitution of Sureties on permit or lease bonds.	Terminates liability	Holds principal and surety responsible for past actions.

1. Potash Prospecting Permits

Under the authority of Title 43 CFR 3510, BLM as delegated by the Secretary of the Interior has authority to issue prospecting permits on unclaimed and undeveloped land for the prospecting of chlorides, sulphates, carbonates, borates, silicates or nitrates of potassium and sodium. After an application for a prospecting permit is adjudicated by BLM, the application is submitted to USGS which determines 1) whether the land applied for contains a known potash deposit of commercial value, or 2) whether there is a known potash deposit of undetermined quality. (See Table I-3 on page I-63 for determinations requested from USGS prior to BLM State Office concurrance.) Prospecting permits are allowed only where there are no known potash deposits of commercial quality. If USGS determines that the land is already established as an area containing commercial quality potash, the prospecting permit will be denied by BLM. If the land has a potash deposit of undetermined quality, USGS may decide that prospecting is necessary to determine the quality and extent of the deposit. The leasing and lease enforcement are carried out by the cooperative efforts of BLM and USGS as established by Secretarial Order 2948.

If USGS determines that prospecting is needed to determine the existence of a workable deposit, the application is returned to the BLM State Office with suggested prospecting stipulations and recommendations for approval. If the State Office concurs with USGS stipulations, a site specific Environmental Analysis Record (EAR) and a Technical Report (43 CFR Part 23 - see Appendix D-2), If the State Office does not concur with USGS stipulations, the dispute is submitted to the Washington office for resolution.

After concurrence between BLM and USGS, these two agencies usually complete the EAR and the Technical Report at the District level. The purpose of the Technical Report is to describe the environmental effects expected from surface exploration, mining and reclamation of the applicable lands. The EAR examines these expected effects and ascertains mitigating and enhancing measures for environmental protection. When these documents are completed they are returned to the BLM State Office along with the application. At this time the application is reviewed for final approval and for delineation of stipulations to be included in the lease. After approved by the State Office the permit is drawn up and the permittee signs, submits bond, and otherwise complies with applicable stipulations of the permit.

Before actual prospecting activities can be initiated, the permittee must file on exploration plan and a notice of intention to drill with the USGS Mining Supervisor, who consults with the BLM District Manager regarding surface protection and reclamation provisions. The permittee is required to comply with the provisions of an approved exploration plan. Adequate bonding is required to guarantee faithful compliance with applicable regulations, with the terms and conditions of the permit and with the exploration plan as approved, amended or supplemented.

During the course of exploration work, it is the responsibility of USGS to enforce the surface protection stipulations. Reclamation commonly involves ripping and seeding but requirements may vary with each site. A final site inspection to assure compliance with stipulations is generally made jointly by BLM and USGS before the performance bond is released.

2. Prospecting Permit Extensions

Under the authority of Subparts 3500.2 and 3511.3, BLM, as delegated by the Secretary of the Interior, may authorize a single two-year permit extension after consultation with the Mining Supervisor of USGS. The USGS determines if the permittee has been unable, with reasonable diligence, to determine the existence or workability of the deposits. The USGS also determines if the permittee has drilled at least one adequate test hole on the permit area or performed other comparable prospecting described in the permit. This requirement may be waived if failure to perform prospecting was directly attributable to the shortage of equipment or essential labor or that failure was because of conditions beyond the permittee's control.

Usually potash permits are extended with the same stipulations as those included in the original permit, although additional stipulations may be added by BLM.

3. Preference Right Leases

Under the authority of Subpart 3500.1-1 and 3520.1-1 BLM as delegated by the Secretary, is authorized to divide the potash area into leasing units and to award leases of mineral lands and mineral deposits. A permittee who discovers valuable potash deposits in the permitted land while his permit is in force is entitled to a preference right lease for all or part of the lands in the permit in a reasonably compact form. Valuation of potash deposits is made by USGS. After USGS determines that a valuable potash deposit has been discovered, a site specific EAR and Technical Report are completed to ensure that adequate environmental protection stipulations are placed in the lease. See Table I-3 page I-63 for USGS determination. Rights granted and retained are listed in Table I-4, page I-66.

4. Non-competitive leases (chargeable)

Under the authority of Subpart 3524.1-2, BLM, as delegated by the Secretary, may issue this type of lease if the BLM and USGS determine that the potassium deposits in the land applied for extend into an active mining unit held by the applicant and are a normal part of such a mining unit. The land applied for must be lacking in sufficient reserves to warrant independent development as a single mining unit, and can not be of competitive interest to holders of other active mining units in the area. These leases provide the highest rate of royalty and an extra royalty assessment in addition to that specified in the lease. Non-competitive leases (chargeable) are included in the lessee total acreage holdings. Leases are offered only after a site specific EAR and Technical Report have been completed to ensure that adequate environmental protection stipulations are included in the lease. See Table I-3 page I-63 for USGS determinations.

5. Non-Competitive Leases (not chargeable - fringe acreage)

Under the authority of Subpart 3524.1-3(c), BLM, as delegated by the Secretary, may issue non-competitive leases which are not charged to the lessee's maximum acreage. The total acreage that can be held in fringe acreage leases is limited to 2,560. A lessee holding acreage approximating 25,600 chargeable acres in federal leases, upon showing that the leased deposits extend into adjoining or adjacent federal land and that the lands containing such deposits are a necessary and normal part of a mining unit, may file an application to have such adjoining or adjacent federal land designated a fringe acreage that will not be chargeable. These leases are issued only after a USGS verification that a fringe ore situation exists, and the EAR and Technical Reports are received from the BLM field offices for the development of environmental protection lease stiuplations.

6. 7. Competitive Leases (applicants motions or Bureau actions)

Under authority of Title 43 CFR Subpart 3521.2, an application, or several, may be filed by prospective lessees or the Bureau may initiate a competitive lease sale on its own motion. The Bureau, in cooperation with USGS, reserves the right to set the leasing units. The government reserves the right to reject any and all bids. An unpublished, acceptable minimum bid per leasing unit is established by USGS and agreed to by BLM. In the event of disagreement, such a conflict will be resolved at the Washington level. In the event that a successful high bidder should refuse the lease offered, the deposit submitted with the bid shall be forfeited. A bid that does not meet the acceptable minimum bid shall be rejected and the deposit will be returned. These competitive offerings only occur after a site specific EAR and Technical Report have been completed to ensure adequate environmental protection stipulations are placed in the lease.

8. Lease Readjustments (Bureau actions)

Under the authority of Subpart 3522.2, potash leases are issued subject to readjustment of terms and conditions of the lease at the end of each 20 year period, unless otherwise provided by law. Notice of the proposed readjustments will be given, wherever feasible, before the expiration of each 20 year period.

The rights granted and retained are the same as those shown for preference right leases. Readjustments are affected by written decision of the BLM and the lessee's execution of current lease forms and attachments. The

EAR and Technical Report are completed to ensure that adequate environmental protection stipulations are included in the lease.

9. Lease or Permit Relinquishments

The permittee has the right to surrender the entire prospecting permit or any legal subdivision thereof, subject to acceptance by the Bureau of Land Management.

10. Assignments of record title to permittees or lessees

Permits or leases may be assigned in total or in part, whole interest or undivided interest. Where leases or permits are assigned as to part of the lands including the whole interest, a new lease is created. Assignment of an undivided interest of less than 100 percent interest, will not create a new lease.

11. Assignment of operating rights

Lessees or permittees sometimes may assign operating rights on the leases or permits to parties who may be interested in obtaining record title to the permits or leases in the future. These sub-leases are created mostly for exploration and prospecting purposes.

12. Substitution of Sureties on permits or lease bonds

For reasons known only to lessees and permittees, sureties are substituted on leases or permits. This is permissible as long as liability has not attached to a given bond, also where leases or permits are assigned, assignees usually put up their own individual bond or bonds.

13. Right-of-Way Grants

In the event the lessee needs to bring electricity, water natural gas, railroad, or road access across adjacent federal lands to develop the potash lease, the lessee or the utility company must file a right-of-way application with the BLM State Director. The District Manager is responsible for site inspection and preparation of the Land Report Title Page and the Environmental Analysis Record (EAR) for the proposed right-of-way. The EAR is prepared first, and it completely analyzes how the granting of the right-of-way would impact the existing environment. The Land Title Report Page is then prepared. It documents all specific information pertaining to the lands action, i.e., information regarding the on-site right-of-way area.

Both documents are used by the decision maker (State Director) to help form the basis for granting or not granting the right-of-way permit.

The nature of interest granted under the provisions of Title 43 CFR 2800, is as follows:

No interest granted by the regulations in this part shall give the holder thereof any estate of any kind in fee in the lands. The interest granted shall consist of an easement, license, or permit in accordance with the terms of the applicable statute; no interest shall be greater than a permit revocable at the discretion of the authorized officer unless the applicable statute provides otherwise. Unless a specific statute or regulation provides otherwise, no interest granted shall give the grantee any right whatever to take from the public lands or reservations any material, earth, or stone for construction or other purpose, but stone and earth necessarily removed from the right-of-way in the construction of a project may be used elsewhere along the same right-of-way in the construction of the same project. The grantee obtains only the right to use the land for the purposes for which the right-of-way is granted, and no other purpose, and may hold such possession if it is necessary to that use, as long and only as long as that use continues.

An applicant, by accepting a right-of-way, agrees and consents to comply with and be bound by the terms and conditions specified in 43 CFR 2801.1-5.

Below are some of the various types of rights-of-way, the Act citations and the regulations applicable to each.

a. Railroad and station grounds (Act of March 3, 1875 (18 Stat. 482; 43 U. S. C. 934-939).

Term is indefinite; 43 CFR Subpart 2842. A railroad company to which a right-of-way is granted does not secure a full and complete title to the land on which the right-of-way is located. The Government conveys the fee simple title in the land over which the right-of-way is granted to the person to whom patent issues for the legal subdivision on which the right-of-way is located, and such patentee takes the fee, subject only to the railroad company's right of use and possession.

b. Water plants and facilities (Act of February 15, 1901 31 Stat. 790; U. S. C. 959) 43 CFR. Subpart 2873.

Term is indefinite. The right-of-way width shall not exceed 50 feet on each side of the centerline.

c. Oil and natural gas pipelines (Section 28 of the Act of February 25, 1920) (41 Stat. 449), as amended by the Act of November 16, 1973 (87 Stat. 576) 43 CFR Part 2800 and 2880.

Term, prior to the amendment by the Act of November 16, 1973, indefinite to the extent of the ground occupied by the said pipeline and 25 feet on each side of the same. After amendment by the Act of November 16, 1973, 30 years subject to renewal. The right-of-way width shall not exceed 50 feet, plus the ground occupied by the pipeline.

d. Power transmission lines, telephone and telegraph lines (Act of February 15, 1901, 31 Stat. 790; 43 U. S. C. 959) or Act of March 4, 1911 (36 Stat. 1253; U. S. C. 961) 43 CFR parts 2850 and 2860.

Term is indefinite. Act of February 15, 1901 - the right-of-way width shall not exceed 50 feet on each side of the centerline. Act of March 4, 1911 the right-of-way width shall not exceed 200 feet on each side of the centerline and not exceed 400 feet by 400 feet for superstructures and facilities. Term is for a period not to exceed 50 years subject to renewal.

e. Tramroads and logging roads (Act of January 21, 1895) (28 Stat. 635; 43 U. S. C. 956) 43 CFR Subpart 2811.

The regulations provide for both temporary and long terms. Temporary usually does not exceed six months.

The Act contains no limitation or duration of this type right-of-way.

The use of the tramroad right-of-way has traditionally been used to permit access to certain types of mining, quarrying, timber sale, and timber manufacturing sites. The interpretation to expand its use to include roads servicing oil and gas, geothermal steam and coal leases, potash leases is being considered.

14. Mining and Reclamation Plan

Once a lease has been issued, the lessee must submit a mining and reclamation plan to the USGS Mining Supervisor before any operations can be conducted. The plan essentially must provide for efficient utilization of minerals, for protection of non-mineral resources and for the reclamation of land surfaces affected by the operations. The Mining Supervisor prepares an environmental analysis on a mining and reclamation plan to determine if lessee operations will significantly affect the environment. If this is the case, an Environmental Impact Statement (EIS) is prepared jointly by USGS and BLM; if not, the plan may be approved under existing laws and regulations.

In accordance with Secretarial Order 2948, when it is determined that an EIS is unnecessary, or the EIS has been completed, the USGS Mining Supervisor consults with the BLM which recommends approval of the plan or indicates what modifications are necessary for the plan to include adequate provisions for surface use, environmental protection and reclamation.

The Mining Supervisor is responsible for ensuring lessee compliance with the mining and reclamation plan and conducts examinations of lessee operations to check for this compliance. BLM is responsible for compliance examinations of environmental protection requirements for portions of the lease outside the imediate environment of the refineries.

Before a mining and reclamation plan is approved, a notice of receipt of the plan is posted in the office of the Mining Supervisor. A notice of the availability of the plan for inspection is sent to the office of the County Clerk in the county where the operations are to take place. In a public review, pertinent comments are solicited. Comments filed within 30 days from the date of the release shall be considered in the preparation of the Environmental Analysis (Figure I-14 in back pocket).

All decisions, of both BLM and USGS, which adversely effect the lessee or permittee may be appealed to the Interior Board of Land Appeals by the effected party.

15. Royalty Collection and Distribution

The USGS is responsible for the collection of royalties on all potash leases. The royalty is paid on the gross value of the product at the point of shipment to market. This has been interpreted and administered to be the sales price received f.o.b. the refinery. The tonnage on which royalty is collected is determined by the railroad scale weight.

Since potash may be mined from three land owner categories - (federal, state, and private) - in the same mine, a commingling system is used to determine royalty due each land owner. Under this system, all of the ore from the mine goes into the refinery together. The raw ore is weighed and sampled before it enters the refinery and the finished product is weighed and sampled before it enters the storage building for efficiency and inventory control.

The federal royalty collected is distributed under the Mineral Leasing Act in the following manner - - 37½ percent to the State, 52½ percent to the reclamation fund, and 10 percent to the U. S. Treasury.

F. Proposed Actions

1. Minerals Applications

The Bureau of Land Management has, for consideration, 243 Minerals Applications, covering an area of 560,553 acres.

Of this total, 226 are prospecting permit applications, covering 533,574 acres. These applications were filed by eighteen different individuals and companies. Only two applicants, AMAX Chemical Corporation and Ideal Basic Industries, Inc. have existing potash mining and refining operations in the study area. Ideal Basic Industries, Inc. owns Potash Company of America, its potash mining and refining operation, at Carlsbad, New Mexico.

There are 16 Competitive Lease Applications, covering 26,179 acres. These applications were filed by four different companies; three - AMAX Chemical Corporation, Kerr-McGee Chemical Corporation, and National Potash Company, have existing potash mining and refining operations in the study area.

There is one non-competitive lease application, covering 800 acres, filed by Mississippi Chemical Corporation. This company has a potash mining and refining operation in the study area.

Refer to Appendix D-8 for a complete summary of all minerals applications. The application area is illustrated on Map I-1 in back pocket.

2. Company Proposals

a. Mississippi Chemical Corporation

Mississippi Chemical Corporation (MCC), is currently designing and engineering a new refining facility which is scheduled to begin production between 1983 and 1985. As an extension of this plan, MCC is pursuing a redrilling test program northeast and southeast of the present refinery site to determine the quality and quantity of potash ore in the tenth ore zone. The company then plans to mine this tenth ore zone and existing ore reserves through a new shaft and hoist which will be erected at the same site as that proposed for the refinery.

Seventh Ore Zone

The proposed shaft is planned to be a 20 foot in diameter, vertical shaft which will be sunk 1550 feet. The shaft will be used to hoist ore from an ore reserve covering approximately 14,000 acres. Since the proposed refinery is expected to produce 600,000 tons of potash salts per year, the company will be hoisting around 4.7 million tons of ore annually.

The new facility, excluding tailings and slime disposal areas, will cover approximately 72 acres on federal land not currently under potassium lease. MCC has applied to BLM for a non-competitive lease on the property.

MCC has stated that air emissions at the new refinery will come from the dryer stack and boiler stack. A dual dust system with cyclones on the dryer discharge and wet scrubbers or bag filters on the cyclones will be used to control dryer stack emissions. The company also reports that boiler stack emissions will contain only air, carbon dioxide and water vapor resulting from the complete combustion of natural gas.

The new refinery, which will use a flotation process with the crystallization of fines, will require 2000 gallons of water per minute. To accommodate this need, MCC plans to build a thirty mile pipeline to transport water from the Caprock where the company holds rights for approximately 3500 acre feet of water.

Southern Union Gas Company will supply MCC's new refinery. Tentative plans are to run a diversion line from Southern Union's existing line now serving the Kerr-McGee Potash Refinery.

The new processing facility will be serviced by a spur of the Santa Fe Railroad, to be constructed from the existing line now servicing the Duval, National and Kerr-McGee Corporation Plants.

For ingress and egress to the proposed plant site, MCC intends to use an existing road which intersects U. S. Highway 180 northwest of the site. A new road running due south will be constructed to link the existing road with the proposed new plant site.

If and when the company builds this proposed plant, the present processing facility will be shut down; the equipment and structure will be dismantled and hauled away. The present No. 1 and No. 2 shafts will be used as escape ways and for ventilation.

See Map II- 25 page II- 355 for the location of the proposed new refinery mine shaft and support facilities. See Map II- 16, page II- 307 for present MCC refinery site.

b. Potash Company of America

Potash Company of America (PCA) is presently engaged in a drilling program on the Hodges leases (also known as the Leonard Trust) in the southern part of the basin (see Map I-3). Twenty-seven holes have been drilled and the company plans to drill 13 more, before evaluating the drilling program. PCA expects significant langbeinite and sylvite ore reserves on these leases since the drilling program presently looks quite favorable.

Two new shafts will be needed to mine the Hodges Lease and a langbeinite refinery may be built near the new shafts, or the present refinery facility may be modified to process the langbeinite ore. Indications now are that the best part of the ore body lies south of Duval Corporation and International Mineral Corporation operations. If a new PCA plant is built, it will be as near the center of this new ore deposit as possible, preferably located on high ground for good drainage.

The company indicates a twenty year supply of ore will be needed to support the necessary capital investment for mining and processing. PCA estimates about a three year lag from the time of a decision to "go ahead" until actual beginning of production. In a new operation, PCA plans for a 150,000 to 250,000 ton per year langbeinite finished product operation which will require about one and one-half million tons of ore annually. The mining and processing of the langbeinite ore will be similar to the other existing langbeinite operations in the basin. The sylvite and langbeinite ores will be mined together and then separated during processing.

PCA has indicated that langbeinite processing requires fresh water. PCA has considerable water rights on the Caprock for new ore processing; however, the company said available water may be a limiting factor of future ore processing. If additional processing capacity is built, a new water line from the Caprock will have to be constructed to support the processing facility.

Railroad freight rates for ore and the handling of waste material will be primary considerations in the decision to build a new refinery or to modify the existing processing facility. Freight rates are already costly and the company has limited space for waste material at the present refinery site.

As for present operations at the existing site, no major changes are contemplated and production is expected to continue at the present rate. The company will mine into the fringe ore zones as much as possible.
In addition to the Hodges leases mentioned above, Potash Company of America holds a state potash lease located in the northeastern portion of the basin near Hobbs, New Mexico (see Map I-4). Here they have a low grade sylvite ore deposit (15-17% K_2O) in the tenth ore zone.

This ore reserve is considerable and has potential for future exploration. Although the company plans no development of this ore reserve within the next five years, at some point beyond this, they will seriously consider development.

Depending upon economic conditions, a new mine and refinery may be built on the state lease. Construction on the state land would have certain impacts on federal lands through the support uses of access roads, waterlines, gaslines, railroad spurs, and powerlines.

The company would also consider processing the ore at the present refinery site. However, solid waste disposal would be a major consideration. The present site is surrounded by a range of hills and space for solid waste disposal is limited. See Map II-17, page II-313 for present PCA refinery site.

c. International Minerals Corporation

International Minerals Corporation (IMC) now mines about 14 thousand tons of ore per day. Plans are under investigation to increase production to about 20 thousand tons of ore per day in roughly three years. No additional leases are anticipated, although the company may apply for limited acreage to mine fringe ore adjacent to their existing leases. In 1975 and 1976, IMC plans to drill 15 test holes to determine the quality and quantity of ore reserves. An additional 15 test holes will be drilled after 1976. Present planning does not anticipate the need for new shafts for at least 10 years, although IMC can see a long-term need for a new shaft located southeast of the refinery. IMC's No. 3 shaft is now used for ventilation. Plans are to refurbish this shaft and use it for hoisting ore. IMC plans to hoist about 10 thousand tons of ore per day from No. 3 and an additional 10 thousand tons from their shaft at the refinery site. An overland conveyor system will be constructed from their No. 3 shaft to their refinery to transport the ore. This will involve a distance of approximately three quarters of a mile and the conveyor will bridge State Highway 31 and the Santa Fe Railroad right-of-way.

IMC is currently looking at a multiphase refurbishment and expansion program, with all the work being done within or adjacent to the existing refinery site. The purpose of this work is to increase production, improve efficiency, and to reduce environmental pollution.

The tentative plan proposes the following actions:

1) Construction of a new product warehouse to be located within or just outside the fenced refinery area. An additional railroad spur located within the present fenced area will be needed to serve the new warehouse.

2) Addition of beneficiation facilities for langbeinite and sylvite ores.

3) Replacement of the present Ozark evaporators with triple effect evaporators.

4) Investigation of the feasibility of boiler conversion from natural gas to coal firing during a natural gas shortage. The conversion may be on only a partial basis.

5) Utilization of additional measures in the present refinery to conserve natural gas.

6) Possible construction of additional holding ponds to contain brine waters.

IMC prefers to handle the proposed expansion without additional water usage. However, if ongoing tests dc not prove favorable, additional water may be necessary. The company would anticipate an increased usage of no more than 3,000 gallons per minute. In this case, one possibility would be to buy water which would be transported the company pipeline. One factor in water selection would be the amount of briney, high gyp-content water the refinery processes could adequately handle. No additional natural gas will be required for the expansion; however, electric power consumption will increase substantially.

On all future operations, the company plans to do whatever is technically feasible to control dust and air emissions from their ore processing and handling. See Map II-18, page II-319 for present IMC refinery site.

d. Duval Corporation

Duval Corporation is planning to expand their langbeinite refinery depending on future market conditions for potash. Such an expansion would require an additional source of water. Duval claims that a 20 percent salt-saturated water solution can be used for leaching in the langbeinite process and the company is considering obtaining the water from the Capitan Reef Aquifer below 2,500 feet.

Duval is also planning to refurbish the old U. S. Potash No. 3 shaft and run two 6,500 foot tunnels northward from the shaft in order to mine approximately a four year supply of sylvite ore. In seeking approval to drill these tunnels, the company has now submitted an interim mining plan to USGS. The company proposes to haul solid waste salt to the present refinery site and dump it onto the existing tailings pile.

The only other surface use associated with this mining activity will be the use of 50-ton trucks to haul the ore from the No. 3 shaft to the present refinery site. An existing road will be used.

Duval is also faced with the problem of abandoning their Wells Weaver mine (see Map I-5) after the hoisting equipment is sold and removed from the site. The problem lies in finding the best solution for abandonment of the open mine shaft. A list of possible options is included in the "Lease Abandonment" section (see page I-50). Map II-19 , page II-325 shows the present Duval refinery site.

e. Amax Chemical Corporation

AMAX Chemical Corporation has very few long range plans at this time. The company does plan to continue operating at a finished product level of approximately 650,000 tons per year until known present ore reserves are exhausted. Mining will probably be expanded into the fringe ore areas adjacent to their existing mine workings, thereby extending the operating life of the present facility. Depending on economic ore cut-off levels, the company may return to recover low grade ore from previously mined areas at any given time.

AMAX proposes to blend ore from the third ore zone (high clay content) with ore from first ore zone (low clay content) to extend the life of their ore reserves. The mining operation will use a slope from the first ore zone to enter the third ore zone from which ore will be transported to the hoisting shaft on the first ore zone level. The company has ordered special low-height mining equipment for use in the third ore zone.

AMAX has filed prospecting permit applications with BLM on federal lands located in outlying areas south of the present refinery site. If the necessary prospecting permits can be obtained, test holes will be drilled. AMAX believes there is about a 10 percent chance of discovering a significant amount of good ore. The ore is probably in the tenth ore zone and there is a possibility both sylvite and langbeinite ores will be discovered.

The quality and quantity of any discovered ore, in addition to many economic factors, will determine whether ore will be processed at the present refinery facility or at a new plant site near the future mine shaft.

In order to economically establish a new mine, the company believes that a minimum ore deposit for langbeinite should be at least twenty million tons and for sylvite, thirty to forty million tons. Map II-20, page II-333 shows AMAX present refinery site.

f. National Potash Company

National Potash Company (NPC) has no long range plans for major mining or refinery expansion. They do indicate a possible need for 1 or 2 new service shafts to the north of their existing operations about 1980 or later (see Map I-5, page I-90). These shafts will provide additional ventilation to the underground mine workings.

NPC is about to abandon their Eddy County mine (see Map I-5). This abandonment proposal has the same possibilities as those described under "Lease Abandonment" (see pages I-51-54). One company has contacted National about using the mine shaft and tunnels for compressed air or natural gas storage, but no decisions have been made.

At some point in the future, the company may need to take an overground tailings line to Laguna Plata (about two miles east of the plant site). This would happen only if the company runs out of tailings disposal area at the present plant site. The tailings pipeline to Laguna Plata would be within their present waterline easement for most of the distance. Map II-21, page II-339 shows the present NPC refinery site.

g. Kerr-McGee Chemical Corporation

Kerr-McGee Chemical Corporation has long term plans which indicate they may need a new service shaft to be located about three miles northeast of the present refinery site. This shaft will be necessary if the mine workings get too far out from the present shaft to get men to and from the job quickly and efficiently. The shaft would be eight feet in diameter, and would be sunk by boring. Map II-22, page II-345 shows present Kerr-McGee refinery site.

h. Day Mines

Day Mines has an exploratory drilling program underway on some of their own leases. In addition, they have a large number of prospecting permit applications. The company plans to continue exploratory drilling if they are able to acquire the necessary prospecting permits. Based on existing knowledge of their drilling, railroad spur locations, federal highways, and other factors, Day Mines has indicated two sites which now appear most favorable as new mine and refinery sites. (See Map I-6)

The mine and refinery may be constructed if the company finds sufficient ore reserves and economic and regulatory factors are favorable.

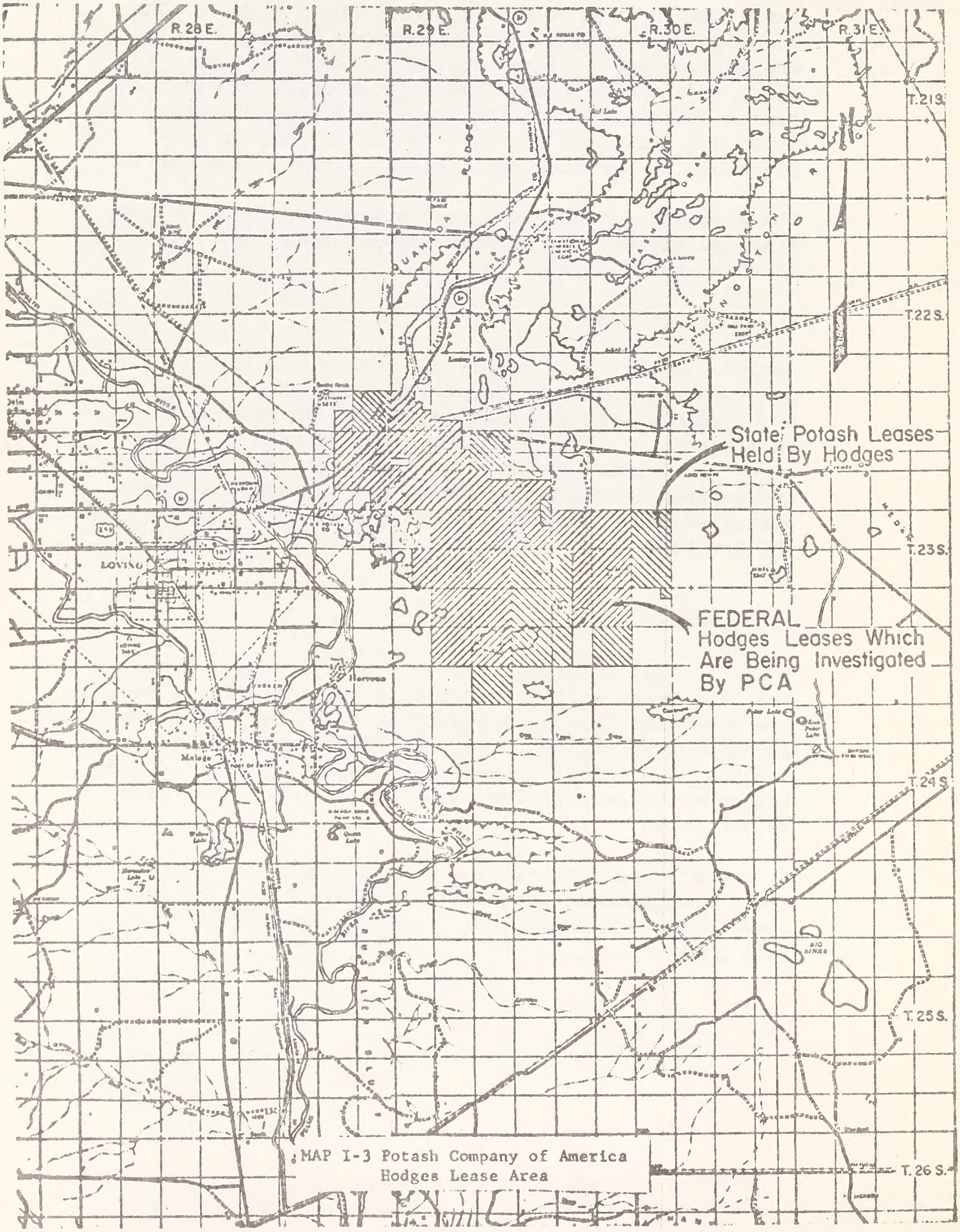
i. Noranda Mines

Noranda is currently involved in an exploration drilling program on the Harroun-Hayworth leases (see Map I-4, page I-89). If this exploration proves successful and an adequate ore body is discovered, Noranda will construct a mine and refinery on these leases. This mine and refinery would be approximately the same as those described under "Typical Potash Operations" (see p. I-15-41). The ore body being explored is sylvite in the tenth ore zone.

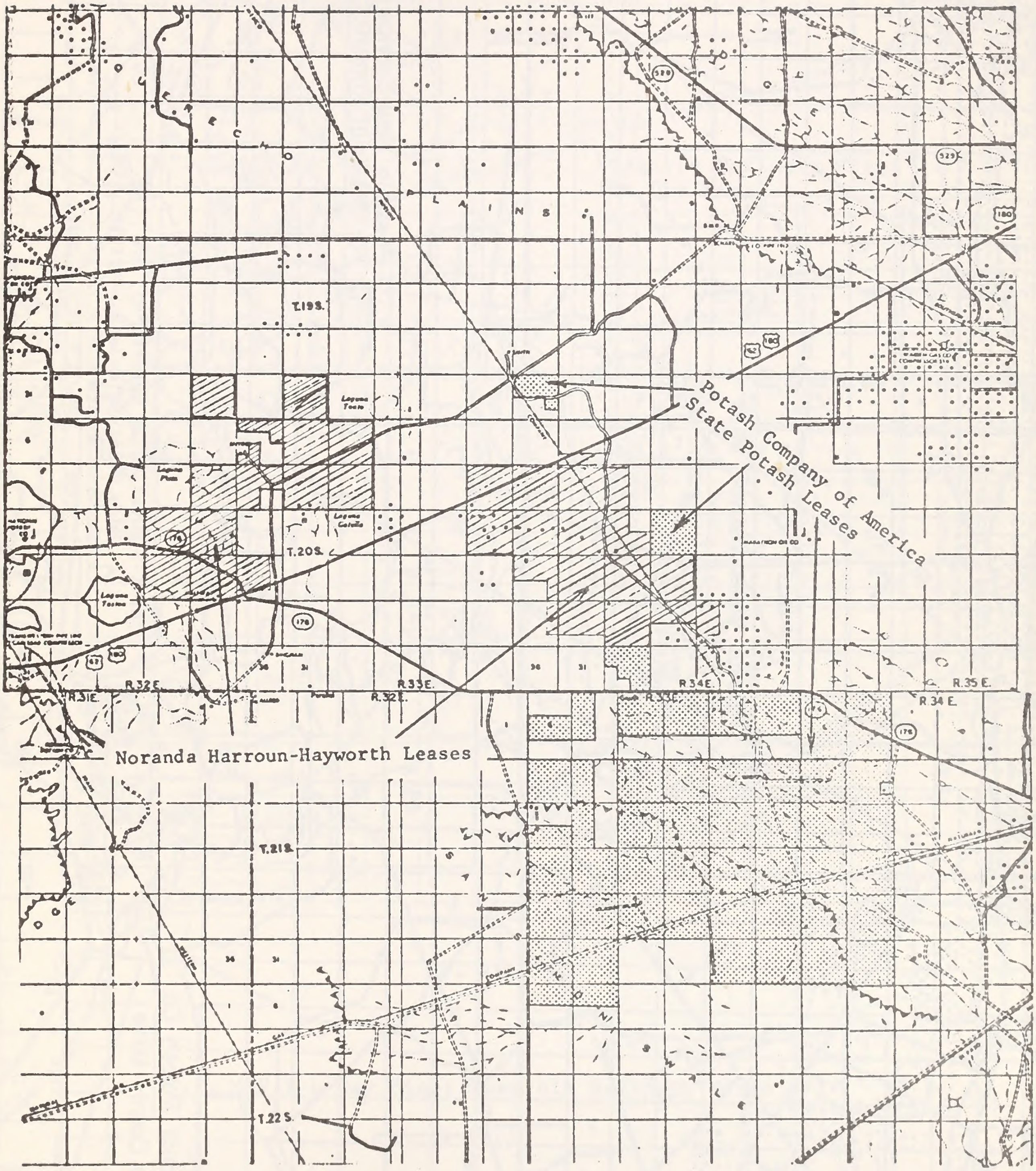
3. Federal Lease Readjustments

There are 117 existing federal potash leases, covering 165,946 acres, within the study area. All these leases are scheduled for readjustment of lease terms at twenty-year adjustment increments. Thirty-five leases are due or are past due for adjustment by October 1, 1975. These leases which are due for readjustment cover an area of 48,806 acres.

A complete list of existing potash leases in order of lease readjustment date is in Appendix D-7. The area covered by each lease is also illustrated on Map I-1 in back pocket.


R.28E.
R.29E.
R.30E.
R.31E.
T.21S.
T.22S.
T.23S.
T.24S.
T.25S.
T.26S.
State Potash Leases Held By Hodges
FEDERAL Hodges Leases Which Are Being Investigated By PCA
LOVING
Malaga
Harroun
BIG SINKS

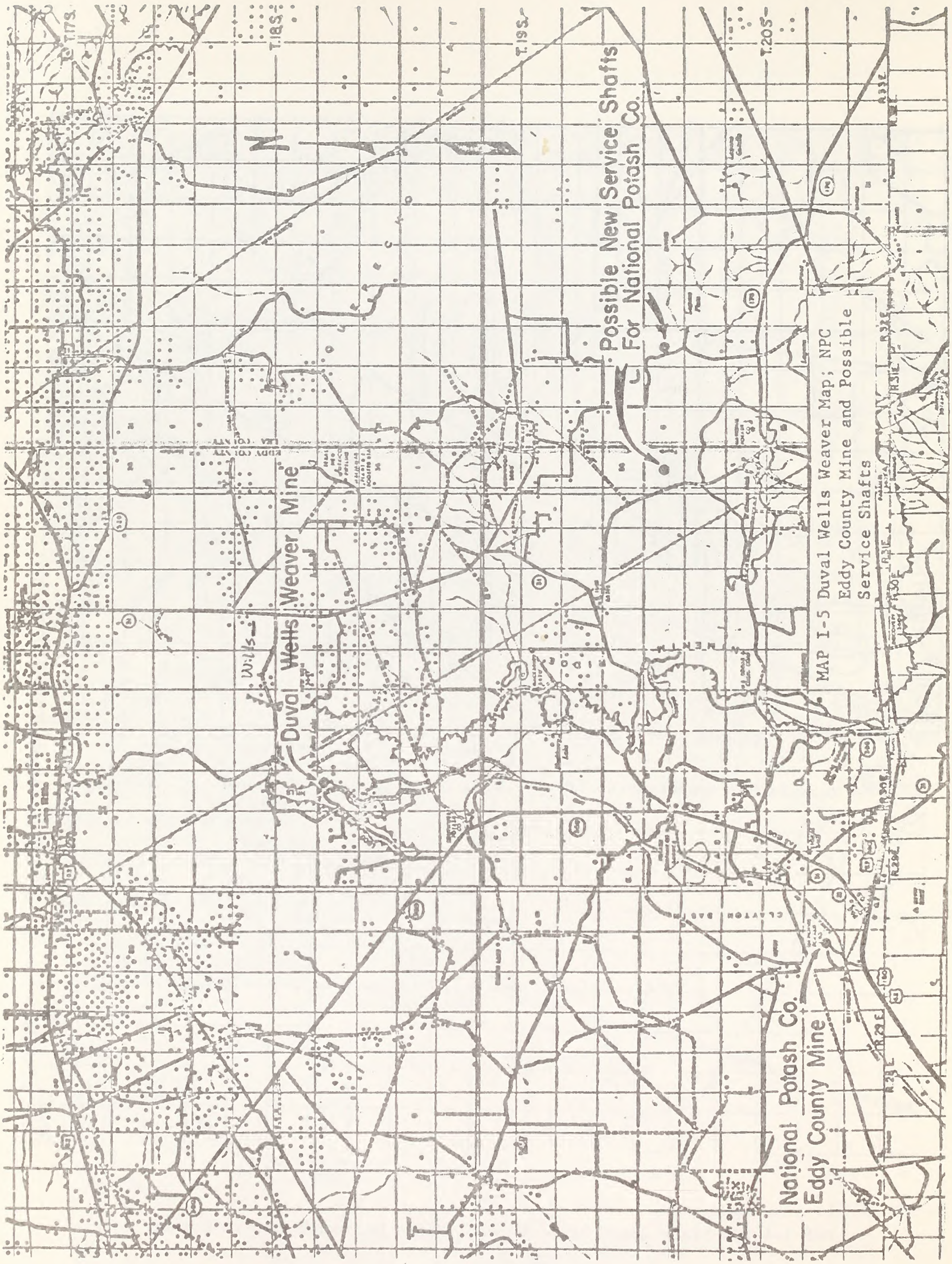
MAP I-3 Potash Company of America Hodges Lease Area



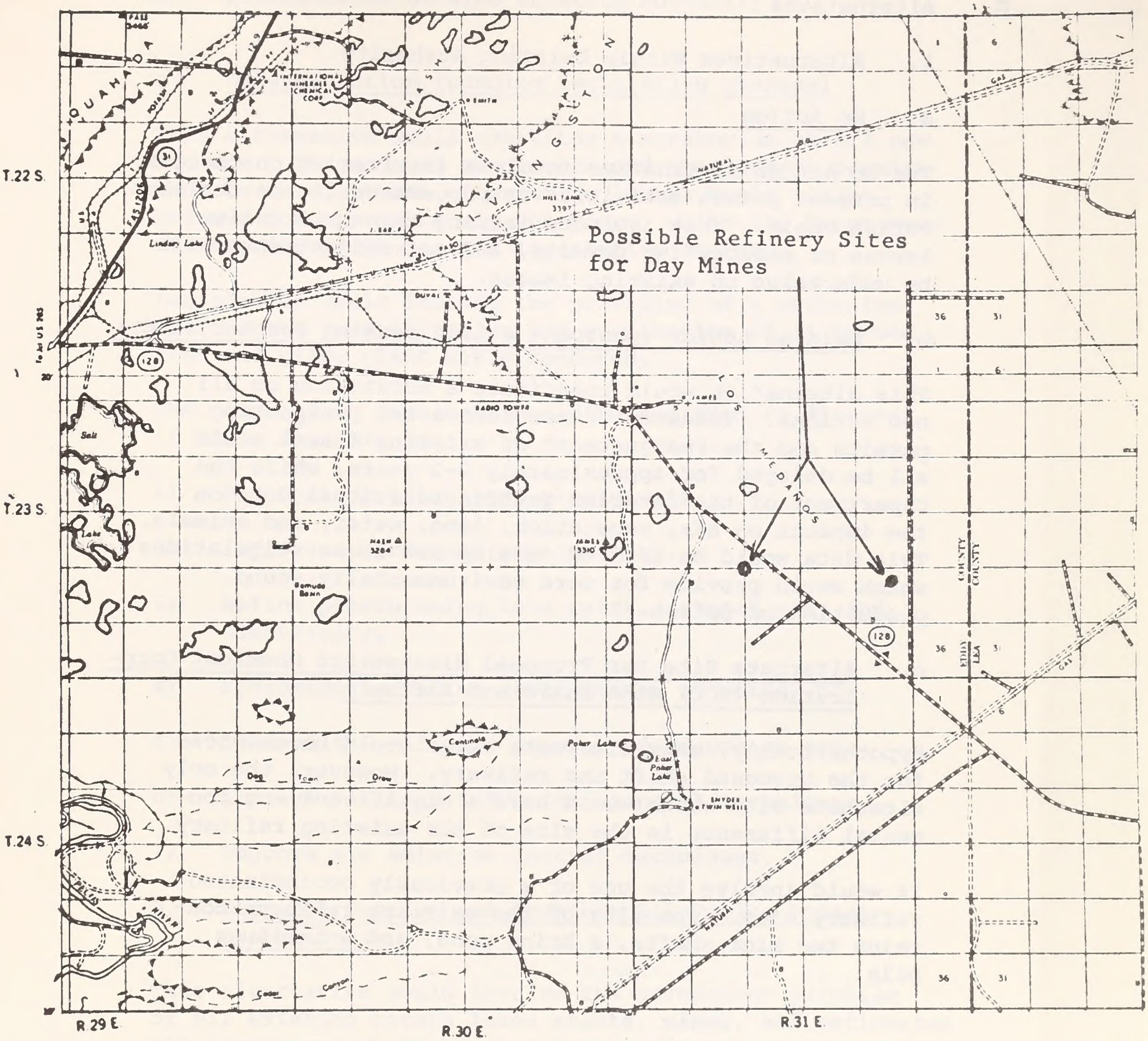
Potash Company of America State Potash Leases

Noranda Harroun-Hayworth Leases

MAP I-4 PCA State Lease Area; Noranda Mines Harroun-Hayworth Leases



MAP I-5 Duval Wells Weaver Map; NPC
Eddy County Mine and Possible
Service Shafts



MAP I-6 Day Mines Possible Refinery Sites

G. Alternatives

1. Alternatives Within Existing Authority

a. No Action

The No Action alternative involves instituting no changes in present potash activities or procedures in the Carlsbad Potash Basin. This includes issuing no new potassium leases or prospecting permits, and no readjustments will be undertaken on existing leases.

b. Delayed Action (postpone action pending further study)

This alternative would constitute a moratorium on all new actions. Issuance of new leases and prospecting permits and the readjustment of existing leases would all be delayed for approximately 2-3 years, while the Department of the Interior gathers additional data on the impacts on air, vegetation, land, water, and animals. This data would be used to develop new lease stipulations which would provide for more environmentally sound production of potash.

c. Alternate Site for Proposed Mississippi Chemical Corporation (MCC) Mine Shaft and Refinery.

Hypothetically, many alternate sites could be selected for the proposed shaft and refinery. However, the only alternate site which would have a significant environmental difference is the site of the existing refinery.

It would involve the use of a previously contaminated refinery site. The site of the existing refinery contains two mine shafts, a brine pond, and a tailings pile.

d. Leaching and Crystallization Refining Process

This alternative would require the use of leaching and crystallization refining process, rather than the more generally used selective flotation refining process. Only one company (Kerr-McGee Chemical Corporation) presently uses the leaching and crystallization process in their refining operations.

The alternative of requiring the leaching and crystallization refining process could be implemented through a restrictive lease stipulation on future potash leases.

2. Alternatives Outside Existing Authority

a. Delayed Action (pending legislative changes)

This alternative would constitue a moratorium on all new actions. Issuance of new leases and prospecting permits and the readjustment of existing leases would all be delayed for approximately ten years, while the Department of Interior seeks certain legislative changes.

Legislation could include the providing of a mechanism to fund the rehabilitation and reclamation of disturbed area and pilot plant scale research.

The pilot plant research should be designed to discover if it is feasible to:

1) Mine potash using less electricity.

2) Improve underground ore recovery.

3) Refine potash using less water, natural gas, and electricity.

4) Economically refine lower grades of potash ore.

5) Improve the refinery recovery from potash ore.

6) Improve tailings and brine disposal techniques.

7) Improve air emission control techniques.

b. Stop All Current and Prohibit All Future Potash Operations.

This alternative would involve the government purchase of all existing potash lease rights, mines, and refineries. All operations would be shut down. Also, no new prospecting permits or leases would be granted.

This alternative would stop all environmental degradation associated with potash operations.

The elimination of the potash industry is not a viable alternative. It will not be considered further because it would not accomplish the purpose of the proposed action, which is to make potassium available for fertilizer.

c. Immediate Readjustment of All Existing Potash Leases

This alternative would involve the immediate readjustment of all existing leases, whether or not they have been in effect for the twenty year adjustment increment. The readjustment would update surface protection stipulations, royalty rates, bonding requirements and other lease items.

This alternative would involve the early mitigation of environmental degredation associated with potash operations.

d. Export and Import Adjustments

This alternative would constitute a reduced potash export level and increase import level to the extent that more potash becomes available for use in the United States. If exportation of potash is decreased while importation is increased to the extent that domestic demand for Carlsbad potash is reduced, the life of the Carlsbad potash ore reserve will be extended. A greatly increased import level would reduce the domestic dependence of potash from the Carlsbad potash basin and the reduced export level would make more potash available domestically from the study area. This situation would not require an accelerated rate of potash development in Carlsbad. If this alternative were selected, congressional action would be required to develop national export and import policy.

e. National Potash Policy

This alternative would call for the development of a national policy to conserve potash to the extent that the life of the Carlsbad potash basin ore reserves are extended.

This alternative could include such measures as follows;

1) Restrict the use of potash for the production of essential food and fiber.

2) Encourage more efficient use of potash through development and implementation of a national soil testing program, which would identify actual potash needs.

Other measures may be available; research and analysis of the above proposed policy could identify such additional measures.

f. Alternate Water Source for Potash Refining

The alternative of an alternate water source would involve securing water for refineries from sources within the potash basin. This would result in pumping water from the brackish ground water in the potash basin and/or recycling refinery waste water, rather than importing fresh water from the Caprock Area and the Capitan Reef Aquifer.

This alternative is not considered to be within existing authority because the State Engineer controls authorizations for water sources. BLM can only indirectly bring about this alternative by a restrictive lease stipulation and prohibiting the authorization of new water pipeline rights-of-ways.

II. Description of the Existing Environment

A. Nonliving Components

1. Air

a. Climate

Climatological information for Carlsbad and Hobbs, New Mexico, for the 30-year period 1931-1960 is summarized in Tables II-1 and II-2 respectively.

(1) Carlsbad

"Carlsbad's climate is semiarid continental with distinct summer-rainfall maxima. Summers are warm and winters are mild. Sunshine is abundant, and relative humidities are low. The Gulf of Mexico is the principal source of moisture for precipitation in this area. The general air circulation is most likely to bring this moisture in summer, with much of the annual total falling during brief but occasionally intense summer thunder showers. Average annual rainfall is about 12 inches, with 80 percent falling in the May-through-October period..... Some of the winter precipitation is snow, which occasionally falls at a rate exceeding 6 inches in 24 hours. However, the mild climate usually prevents its lying on the ground for more than a few hours."

"The high temperature exceeds 90 degrees on most days from mid-May to mid-September. On an average, 27 days a year have a maximum temperature of at least 100 degrees. Because the daily range is usually more than 30 degrees, due to rapid cooling after sunset combined with generally low humidities, most nights are comfortably cool. Winters are mild, dry and sunny. January, the coldest month, has an average daytime shade temperature of near 60 degrees, with the thermometers rarely remaining below the freezing point. During mid-winter, two-thirds of the nights have readings of 32 degrees or lower, but in the 30 years summarized only 11 days had readings of zero or lower. Carlsbad's average growing season is slightly over seven months long, beginning with April 3 as the average date of the last 32 degree or lower temperature in the spring and ending November 5, the average date of the first 32 degree or lower temperature in the fall."

TABLE II-1: Climatological Summary for Carlsbad, New Mexico (1931-1960)

Latitude: $32^{o}25'$N
Longitude: $104^{o}14'$W
Elevation (Ground): 3120 feet

Month	Temperature (°F)							**	Precipitation Totals (Inches)								Mean number of days					Month
	Means			Extremes								Snow, Sleet						Temperatures				
																		Max.		Min.		
Month	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Mean degree days	Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Greatest daily	Year	Precip. .10 inch or more	90° and above	32° and below	32° and below	0° and below	Month
(a)	30	30	30	30	--	30	--	30	30	30	--	30	30	--	30	--	30	30	30	30	30	(a)
Jan.	59.1	28.5	43.8	83	1948	- 4	1947	660	0.44	0.75	1958	0.8	8.4	1947	8.0	1949	1	0	1	22	*	Jan.
Feb.	64.6	32.1	48.4	88	1957	-17	1933	460	0.37	0.96	1932	0.3	4.8	1951	3.0	1951	1	0	*	15	*	Feb.
Mar.	71.4	38.1	54.8	98	1946	9	1932	320	0.46	1.44	1941	0.6	5.0	1947+	5.0	1947+	1	*	*	8	0	Mar.
Apr.	80.2	46.4	63.3	100	1943+	24	1939	120	0.54	1.65	1931	T	0.1	1939	0.1	1939	1	4	0	1	0	Apr.
May	87.7	55.0	71.4	108	1934	34	1934	0	1.76	3.41	1959	0	0	--	0	--	3	15	0	0	0	May
June	95.9	63.9	79.9	111	1939	45	1931	0	1.33	3.70	1948	0	0	--	0	--	2	26	0	0	0	June
July	96.1	66.7	81.4	110	1933	52	1938	0	1.56	2.25	1950	0	0	--	0	--	3	28	0	0	0	July
Aug.	95.5	66.0	80.8	110	1944	52	1955	0	1.60	2.15	1942	0	0	--	0	--	3	27	0	0	0	Aug.
Sept.	89.1	59.3	74.2	106	1948	38	1942	0	1.94	2.35	1932	0	0	--	0	--	3	17	0	0	0	Sept.
Oct.	79.5	48.7	64.1	101	1934	26	1960	100	1.61	4.30	1945	0	0	--	0	--	3	5	0	*	0	Oct.
Nov.	67.6	35.3	51.5	92	1934	- 1	1957	410	0.35	0.90	1944	0.3	5.0	1957	5.0	1957	1	*	*	12	*	Nov.
Dec.	60.2	29.3	44.7	86	1933	- 4	1953	630	0.47	1.30	1942	1.1	11.5	1960	7.0	1931	1	0	*	21	*	Dec.
Year	78.9	47.4	63.2	111	June 1939	-17	Feb. 1933	2700	12.43	4.30	Oct. 1945	3.1	11.5	Dec. 1960	8.0	Jan. 1949	23	122	1	79	*	Year

* Less than one half.

** Base 65° F (estimated).

(a) Average length of record, years.

T Trace, an amount too small to measure.

+ Also on earlier dates, months, or years.

ϕ Partial year's record considered.

From Von Eschen, 1961.

TABLE II-2: Climatological Summary for Hobbs, New Mexico (1931-1960)

Latitude: 32°42'N
Longitude: 103°08'W
Elevation (Ground): 3615 feet

Month	Temperature (°F)							Mean degree days **	Precipitation Totals (Inches)								Mean number of days					Month
	Means			Extremes								Snow, Sleet						Temperatures				
																		Max.		Min.		
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year		Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Greatest daily	Year	Precip. .10 inch or more	90° and above	32° and below	32° and below	0° and below	
(a)	30	30	30	30	--	30	--	30	30	30	--	30	30	--	30	--	30	30	30	30	30	(a)
Jan.	56.4	27.0	41.7	83	1953	- 3	1948+	720	0.46	1.01	1944	1.4	7.7	1948	4.5	1944	1	0	1	23	*	Jan.
Feb.	61.0	30.8	45.9	87	1940+	- 1	1951	530	0.38	0.87	1921	0.5	3.0	1924+	3.0	1924	1	0	1	17	*	Feb.
Mar.	67.5	35.8	51.6	93	1946	1	1922	420	0.40	0.95	1941	1.0	10.0	1958	6.5	1941	1	*	*	11	0	Mar.
Apr.	76.5	45.1	60.8	98	1928ϕ	17	1939	170	0.89	1.87	1926	0.3	8.0	1942	8.0	1942	2	2	0	2	0	Apr.
May	84.3	54.1	69.2	107	1951	34	1938	10	1.97	4.10	1947	0	0	--	0	--	3	9	0	0	0	May
June	92.7	63.2	77.9	110	1960+	37	1939	0	1.67	4.04	1921	0	0	--	0	--	3	22	0	0	0	June
July	93.0	65.6	79.4	110	1958	47	1939	0	2.09	3.53	1960	0	0	--	0	--	3	24	0	0	0	July
Aug.	92.8	65.7	79.1	107	1952	45	1939	0	1.73	2.80	1932ϕ	0	0	--	0	--	3	24	0	0	0	Aug.
Sept.	86.9	58.8	72.9	109	1939	34	1948	0	2.26	4.62	1950	0	0	--	0	--	3	12	0	0	0	Sept.
Oct.	76.6	48.2	62.5	98	1947	23	1925	140	1.93	2.62	1960	T	T	1958	T	1958	3	2	0	*	0	Oct.
Nov.	65.4	35.1	50.3	88	1952	9	1957+	440	0.37	0.78	1940	0.2	4.0	1944	2.0	1944	1	0	*	11	0	Nov.
Dec.	57.9	29.0	43.3	84	1922	1	1926+	670	0.53	1.86	1942	1.4	8.0	1960	5.0	1960+	1	0	1	21	0	Dec.
Year	75.9	46.5	61.2	110	June 1960+	- 3	Jan. 1948+	3100	14.68	4.62	Sept. 1950	4.8	10.0	Mar. 1958	8.0	Apr. 1942	25	95	3	85	*	Year

* Less than one half.
** Base 65° F (estimated).
(a) Average length of record, years.

T Trace, an amount too small to measure.
+ Also on earlier dates, months, or years.
ϕ Partial year's record considered.

From Von Eschen, 1961.

"Approximately five years of wind records made at Carlsbad Airport show an average hourly wind speed for the year of 12.2 miles per hour. March is the windiest month having an average hourly speed of 16.3 miles per hour, and September has the least wind with an average of 9.7 miles per hour. Speeds are less than 13 miles per hour 64 percent of the time, from 13 to 31 miles per hour 33 percent of the time, and exceed 31 miles per hour only 3 percent of the time. The wind blows from the southeast more often than from any other direction, but usually becomes southwesterly during midwinter." (Houghton, 1966).

(2) Hobbs

Hobbs has a semiarid continental climate, characterized by warm summers, cool, dry winters, and abundant sunshine. Practically all moisture received in the area originates in the Gulf of Mexico. Winds bringing this moisture into New Mexico are most favorable during the summer. Consequently, almost 80 percent of the annual 15 inches of rain falls during the 6 month periods, May through October. Small tornadoes have been reported in the county, but no serious damage or loss of life has occurred during the period of record. Some winter precipitation falls as snow, but the average annual snowfall is less than 5 inches, with a maximum 24-hour fall of only 8 inches.

Summers are relatively warm, with the high temperature exceeding 90° on 2 days out of 3. However, there are on an average only about 10 days a year when the temperature exceeds 100°. Considerable cooling at night normally relieves the discomfort of the warm summer days. Winters are mild and sunny. Daytime readings in midwinter usually range from 50° to 60°, and normally no more than 3 days a year have temperatures that fail to rise above freezing. The average hourly wind velocity is about 12 miles per hour throughout the year. March is usually the windiest month, with velocities of 15 miles per hour; in October, the least windy month, the average hourly velocity is 10 miles per hour. Wind velocities above 24 miles per hour can be expected only about 4 percent of the time. The wind blows from the south more often than from any other direction.

(3) Potash Company of America Refinery Weather Station

In addition to the weather stations at Carlsbad and Hobbs, precipitation data is also available from the PCA refinery located about one-third of the way between Carlsbad and Hobbs. Table II-3 summarizes the precipitation measured at the PCA refinery from 1936-1974. For the entire 39 year record, the average annual precipitation was 13.10 inches. For the period of record in Tables II-1 and II-2, the average annual rainfall were as follows:

Carlsbad - 12.43 in.
PCA refinry - 12.80 in.
Hobbs - 14.68 in.

A comparison of rainfall for four area locations for the period 1953-1971 is shown in Table II-4. This table indicates that the rainfall is higher near the potash refineries. Additional rainfall intensity information is available from Tuan, 1973.

b. Meteorology

The distribution of atmospheric pollutants is related to certain meteorological factors. These factors can be considered at two levels, those related to general dispersion characteristics, and those related to specific diffusion calculations.

(1) General Dispersion

General dispersion characteristics are related to the general dispersion of air pollutants in an area. The general characteristics for the potash area are quite conducive to good dispersion and the prevention of air stagnation. Tables II-5 through II-7 contain a summary of various parameters related to general dispersion. Mixing heights referred to in Table II-5 can be defined as the vertical distance above the earth's surface, at a given location and for a given time period, available for the mixing of pollutants. The afternoon mixing heights in southeastern New Mexico are 4 to 5 times greater than the morning mixing heights. Afternoon wind speeds are generally 1.0 to 2.0 meters/second (m/sec) greater than the morning values. The dispersion potential is minimal during winter mornings. It should be noted that even during the minimal periods, the general dispersion is good in southeastern New Mexico when compared to many locations in the eastern and western United States.

Table II-3

PRECIPITATION AT THE POTASH COMPANY OF AMERICA REFINERY 1936-1974

Year	Total (in.)
1936	11.31
1937	13.66
1938	12.18
1939	9.96
1940	11.66
1941	32.37
1942	16.29
1943	11.02
1944	15.84
1945	6.94
1946	9.99
1947	5.99
1948	11.21
1949	13.68
1950	10.36
1951	8.14
1952	7.07
1953	7.27
1954	8.30
1955	17.55
1956	7.21
1957	12.86
1958	24.32
1959	11.45
1960	23.42
1961	10.46
1962	8.98
1963	11.81
1964	6.12
1965	16.58
1966	12.39
1967	8.03
1968	15.68
1969	19.95
1970	12.77
1971	18.18
1972	14.67
1973	14.54
1974	20.50

From Potash Company of America Refinery Records, 1965.

Table II-4

ANNUAL PRECIPITATION DATA IN CARLSBAD AREA, 1953-1971

Station	Period Analyzed	Annual Average	Annual High	Extreme Low
Carlsbad	1953-71	10.34	21	3.5
Potash Mine (Duval)	1955-71	13.52	29	7.8
Potash Mine (PCA)	1955-71	13.79	24	6.1
Jal	1955-71	11.33	21	4.6

From Draft Environmental Analysis Record of Potash Plants, BLM, 1974.

Table II-5

ATMOSPHERIC MIXING HEIGHTS AND WIND SPEEDS FOR SOUTHEASTERN NEW MEXICO

Parameter	Parameter Value
Morning Mixing Heights:	
Annual	460 m.
Winter	310 m.
Spring	500 m.
Summer	680 m.
Autumn	440 m.
Afternoon Mixing Heights:	
Annual	2400 m.
Winter	1400 m.
Spring	2850 m.
Summer	3200 m.
Autumn	2000 m.
Wind Speed Averaged thru the Morning Mixing Layer:	
Annual	6.0 m./sec.
Winter	5.0 m./sec.
Spring	7.0 m./sec.
Summer	6.5 m./sec.
Autumn	5.2 m./sec.
Wind Speed Averaged thru the Afternoon Mixing Layer:	
Annual	7.0 m./sec.
Winter	7.2 m./sec.
Spring	9.0 m./sec.
Summer	6.5 m./sec.
Autumn	6.0 m./sec.

Mixing Height: A measure of the vertical distance available for the mixing of pollutants and it accounts for the effect of inversions.

From Holzworth, 1972

Table II-6

EPISODES (EVENTS) AND EPISODE-DAYS FOR SOUTHEASTERN NEW MEXICO

Parameter		Parameter Value*
Total number of episode-days in 5 years with mixing heights indicated, wind speeds as indicated and no significant precipitation -- episodes lasting at least 2 days.		
Mixing Height ≤500 m.	Wind Speed ≤2.0 m./sec.	0
≤500	≤4.0	0
≤500	≤6.0	1 (W)
≤1000	≤2.0	0
≤1000	≤4.0	15 (W)
≤1000	≤6.0	30 (W)
≤1500	≤2.0	5 (W)
≤1500	≤4.0	25 (W)
≤1500	≤6.0	100 (W)
Mixing Height ≤2000 m.	Wind Speed ≤2.0 m./sec.	2 (W)
≤2000	≤4.0	90 (W)
≤2000	≤6.0	120 (W)
--Same conditions, but for episodes lasting at least 5 days.		
Mixing Height ≤500 m.	Wind Speed ≤4.0 m./sec.	0
≤500	≤6.0	0
≤1000	≤4.0	0
≤1000	≤6.0	0
≤1500	≤4.0	0
≤1500	≤6.0	0
≤2000	≤4.0	0
≤2000	≤6.0	30 (W)

*Number refers to episode-days in a 5-year period; (W) = winter.

Episode: The increase of pollution as a result of stagnation, which is a cessation of horizontal winds and suppression of vertical convection for a specified period of time, with no precipitation and upper limits on mixing height and wind speed determined by the following matrix. Episodes can be determined for any combination of the following wind speeds and mixing heights.

Wind speed m./sec.	Mixing height, m 500	1000	1500	2000
2				
4				
6				

Episode day: Occurrence of the following conditions continuously for at least two days; mixing height - 1500m., windspeed averaged through mixing layer 4 m./sec., and no significant occurrence of precipitation.

:≤ less than or equal to

From Holzworth, 1972

Table II-7

ATMOSPHERIC INVERSIONS FOR SOUTHEAST NEW MEXICO

Parameter	Parameter Value
Inversion Frequency (% of total hours)	
Winter	45
Spring	32
Summer	25
Fall	35
Annual	36
Inversion Percent Frequency (maximum observed)	
Winter	80
Spring	69
Summer	70
Fall	71
Annual	71
Percent Frequency of Nighttime Cloud Cover ($\leq$ 3/10)	
Winter	60
Spring	60
Summer	55
Fall	75
Annual	65
Percent Frequency of Nighttime Wind Speed ($\leq$ 7 mph)	
Winter	40
Spring	25
Summer	30
Fall	45
Annual	35
Isopleths of Nighttime: $(\% \text{ cloud cover} \leq 3/10) + \dfrac{\% \text{ wind speed } \leq 7 \text{ mph}}{2}$	
Winter	52
Spring	40
Summer	50
Fall	45
Annual	45

: $\leq$ less than or equal to

From Holser, 1961

Table II-6 summarizes the number of episodes (events) and episode-days in southeastern New Mexico over a 5-year period.

An episode in this context refers to the persistence of the meteorological conditions as noted, for at least a two-day period. For example, a mixing height equal to or less than 500 meters, wind speed equal to or less than 6.0 meters/sec., and no precipitation for 2 days has occurred only once in southeastern New Mexico in a 5-year period.

Table II-7 provides information on the frequency of temperature inversions in southeastern New Mexico. Inversions occur when temperature increases with height above the earth's surface. Poor dispersion of atmospheric pollutants are characteristic of inversion conditions. On an annual basis, temperature inversions occur 36 percent of the time in southeastern New Mexico.

(2) Specific Diffusion Factors

The two basic factors that influence movements of pollutants from their point of origin to some other location and which must be understood in order to accomplish diffusion calculations for air pollutants are horizontal wind speed and direction, and the vertical temperature structure of the atmosphere.

The wind speed and direction for the area was procurred from the STAR Climatological Program of the National Climactic Center in Asheville, North Carolina. A summary of wind speed and direction for a three-year period (1949, 1953, 1954) is shown in Table II-8. These values result from 24 observations per day. The average annual wind speed is 10.7 knots per hour. The wind blew out of the SE, SSE, S, SSW, and SW for 14,187 observations out of 26,264 total observations, or 54% of the time. The data for the Hobbs station was utilized since it is the nearest station to the potash area for which data was available.

Wind speed and vertical temperature structures are combined into a term called atmospheric stability, with representative values shown in Table II-9. The class A category indicates the greatest amount of pollutant spreading in the most unstable atmospheric conditions, while the class F category indicates the least amount of spreading in the most stable atmospheric conditions.

Table II-8

ANNUAL WIND FREQUENCY DISTRIBUTION
1949, 1953, 1954 *(SUMMARY)
SPEED (KNOTS)
Hobbs, N. M.

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	127	206	303	266	169	56	10.6	1207
NNE	46	83	202	241	173	78	13.1	823
NE	154	232	492	405	204	89	11.0	1576
ENE	50	81	234	217	75	23	10.9	680
E	143	219	413	244	69	7	8.8	1095
ESE	71	192	427	284	71	12	9.6	1057
SE	249	447	1206	687	219	25	9.6	2833
SSE	76	211	786	825	338	71	11.7	2307
S	216	465	1615	1083	383	26	10.4	3788
SSW	95	266	866	579	202	59	10.7	2067
SW	179	366	1254	752	421	220	11.5	3192
WSW	57	104	428	387	216	151	13.1	1343
W	84	122	478	273	101	77	11.0	1135
WNW	45	77	213	172	79	95	12.6	681
NW	125	219	527	260	171	93	10.7	1395
NNW	28	72	165	135	78	40	11.8	518
AVG	2.8	4.9	8.8	13.5	18.0	25.3	10.7	
TOTAL	1745	3362	9689	6810	2969	1122		

TOTAL NUMBER OF OBSERVATIONS	26264
TOTAL NUMBER OF CALMS	567

* Only data which provides stability classifications.

Table II-9

KEY TO STABILITY CATEGORIES

Surface Wind Speed At Ten Meters Height m./sec.	INSOLATION STABILITY CLASSES*				
	Day			Night	
	Strong (1)	Moderate (2)	Slight (3)	Thinly Overcast or < ½ Cloud (4)	Clear to < ½ Cloud
<2 (4.5 mph)	A	A - B	B	-	-
2-3 (4.5-6.7)	A - B	B	C	E	F
3-5 (6.7-11)	B	B - C	C	D	E
5-6 (11-13.5)	C	C - D	D	D	D
<6 (<13.5 mph)	C	D	D	D	D

(1) Sun 60° above horizontal; sunny summer afternoon; very convective

(2) Summer day with few broken clouds

(3) Sunny fall afternoon; summer day with broken low clouds; or summer day with sun from $15\text{-}35^{\circ}$ with clear sky

(4) Winter day

Class A indicates greatest amount of spreading and most unstable atmospheric conditions and Class F indicates least spreading and most stable atmoshperic conditions.

* Insolation: amount of sunshine

From Holzworth, 1972.

The stability observations for Hobbs, New Mexico are shown in Tables II-10 through II-15 for stability classes A through F, respectively. This information was used in the diffusion calculations to be discussed subsequently. (See Table II-16).

c. Air Quality

Air quality measurements in New Mexico are the responsibility of the Environmental Improvement Agency. The State of New Mexico is divided into eight Air Quality Control Regions as shown in Figure II-1, with the potash area being in the Pecos-Permian Basin Intrastate Region which includes Quay, Curry, DeBaca, Roosevelt, Chaves, Eddy and Lea Counties. (EPA, AP-102, 1972)

The ambient air quality in the Pecos-Periain Region can be described by considering observed air quality measurements in relation to ambient air standards. Air quality data for stations in the Region were procurred from the National Aerometric Data Bank of the Environmental Protection Agency. A detailed presentation of the observed values are in Table II-17. Ten stations are located in the Region, with 7 reporting on sulfur dioxide, and all 10 on particulates.

The New Mexico ambient air quality standards for New Mexico are shown in Table II-18, and the National standards are presented in Table II-19. Table II-20 contains a summary of the air quality observations in Table II-17 in relation to standards. The stations at Lovington and Tucumcari are the only 2 that did not exceed the particulate standards. No stations exceeded the sulfur dioxide standards. One possible explanation for the exceedance of the particulate standards is that this area is frequently subjected to dust storms. (Tuan, 1973) Data on frequency of dust storms in this area is not available.

With regard to air quality, Chaves County in the Pecos-Permian Region has been designated as an air quality maintainance area, with carbon monoxide as the problem pollutant. (Air Quality Control Regulation No. 706, 1974) The potash industry is not affected by this designation. "Air Quality Maintenance Area" means that

Table II-10

ANNUAL CLASS A STABILITY FREQUENCY DISTRIBUTION, HOBBS, NEW MEXICO, 1949, 1953, 1954
SPEED (KNOTS)

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	2	4	0	0	0	0	3.8	6
NNE	0	5	0	0	0	0	4.2	5
NE	8	6	0	0	0	0	3.4	14
ENE	2	3	0	0	0	0	4.0	5
E	10	9	0	0	0	0	3.7	19
ESE	7	7	0	0	0	0	3.6	14
SE	8	10	0	0	0	0	3.7	18
SSE	13	7	0	0	0	0	3.4	20
S	12	12	0	0	0	0	3.6	24
SSW	3	5	0	0	0	0	3.9	8
SW	3	6	0	0	0	0	3.6	9
WSW	4	4	0	0	0	0	3.8	8
W	3	1	0	0	0	0	3.3	4
WNW	2	1	0	0	0	0	3.0	3
NW	6	1	0	0	0	0	2.7	7
NNW	0	3	0	0	0	0	4.7	3
AVG	2.7	4.5	0.0	0.0	0.0	0.0	2.7	
TOTAL	83	04	0	0	0	0		

NUMBER OF OCCURRENCES OF A STABILITY - 226

NUMBER OF CALMS WITH A STABILITY - 59

Table II-11

ANNUAL CLASS B STABILITY FREQUENCY DISTRIBUTION, HOBBS, NEW MEXICO, 1949, 1953, 1954
SPEED (KNOTS)

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	17	20	12	0	0	0	5.0	49
NNE	4	11	4	0	0	0	5.4	19
NE	46	23	29	0	0	0	4.9	98
ENE	12	14	19	0	0	0	5.6	45
E	17	26	26	0	0	0	5.3	69
ESE	13	27	36	0	0	0	6.2	76
SE	30	39	69	0	0	0	6.0	138
SSE	14	29	49	0	0	0	6.2	92
S	48	32	52	0	0	0	5.4	132
SSW	28	30	38	0	0	0	5.5	96
SW	36	26	30	0	0	0	5.0	92
WSW	12	13	14	0	0	0	5.4	39
W	20	7	13	0	0	0	4.6	40
WNW	3	9	5	0	0	0	5.4	17
NW	16	11	7	0	0	0	4.5	34
NNW	2	5	1	0	0	0	4.6	8
AVG	2.8	5.1	7.8	0.0	0.0	0.0	5.2	
TOTAL	318	322	404	0	0	0		

NUMBER OF OCCURRENCES OF B STABILITY - 1103

NUMBER OF CALMS WITH B STABILITY - 59

Table II-12

ANNUAL CLASS C STABILITY FREQUENCY DISTRIBUTION,
HOBBS, NEW MEXICO, 1949, 1953, 1954
SPEED (KNOTS)

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	6	15	58	14	3	0	8.6	96
NNE	1	6	45	15	3	0	9.5	70
NE	7	21	77	17	4	0	8.7	126
ENE	2	8	65	20	4	0	9.6	99
E	3	22	72	27	0	0	9.0	124
ESE	0	11	89	34	7	0	9.8	141
SE	10	22	200	86	31	0	10.5	349
SSE	2	22	154	107	23	1	10.8	309
S	10	27	250	126	32	4	10.6	449
SSW	5	28	143	83	19	8	10.7	286
SW	10	32	175	54	28	14	10.6	313
WSW	4	13	65	39	10	12	11.8	143
W	7	15	43	12	5	3	9.0	85
WNW	2	6	35	6	1	3	10.0	53
NW	8	11	46	4	2	2	8.3	73
NNW	4	3	20	3	0	0	7.7	30
AVG	2.6	5.0	8.9	13.1	17.7	26.1	10.1	
TOTAL	81	262	1537	647	172	47		

NUMBER OF OCCURRENCES OF C STABILITY - 2775

NUMBER OF CALMS WITH C STABILITY - 29

Table II-13

ANNUAL CLASS D STABILITY FREQUENCY DISTRIBUTION, HOBBS, NEW MEXICO, 1949, 1953, 1954

SPEED (KNOTS)

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	18	26	125	252	166	56	14.2	643
NNE	12	19	97	226	170	78	15.3	602
NE	30	53	237	388	200	89	13.6	997
ENE	8	21	100	197	71	23	13.1	420
E	25	29	161	217	69	7	11.6	508
ESE	13	39	175	250	64	12	11.8	553
SE	25	44	378	601	188	25	12.4	1261
SSE	16	31	256	718	315	70	13.9	1406
S	21	41	412	957	351	22	13.1	1804
SSW	6	40	276	496	183	51	13.3	1052
SW	21	39	306	698	393	206	14.9	1663
WSW	6	15	118	348	206	139	15.9	832
W	8	11	69	261	96	74	15.2	519
WNW	1	5	39	166	78	92	16.9	381
NW	8	17	97	256	169	91	15.3	638
NNW	1	10	49	132	78	40	15.1	310
AVG	2.7	4.9	9.0	13.5	18.0	25.3	13.9	
TOTAL	219	440	2895	6163	2797	1075		

NUMBER OF OCCURRENCES OF D STABILITY - 13656

NUMBER OF CALMS WITH D STABILITY - 67

Table II-14

ANNUAL CLASS E STABILITY FREQUENCY DISTRIBUTION,
HOBBS, NEW MEXICO, 1949, 1953, 1954
SPEED (KNOTS)

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	0	40	188	0	0	0	7.9	228
NNE	0	10	56	0	0	0	8.2	66
NE	0	40	149	0	0	0	7.8	189
ENE	0	18	50	0	0	0	7.5	68
E	0	36	154	0	0	0	7.7	190
ESE	0	34	127	0	0	0	7.6	161
SE	0	86	559	0	0	0	8.0	645
SSE	0	43	327	0	0	0	8.3	370
S	0	83	901	0	0	0	8.4	984
SSW	0	46	409	0	0	0	8.3	455
SW	0	47	743	0	0	0	8.5	790
WSW	0	7	231	0	0	0	8.8	238
W	0	17	353	0	0	0	8.7	370
WNW	0	15	134	0	0	0	8.4	149
NW	0	24	377	0	0	0	8.4	401
NNW	0	9	95	0	0	0	8.6	104
AVG	0.0	4.9	8.7	9.0	0.0	0.0	8.3	
TOTAL	0	555	4853	0	0	0		

NUMBER OF OCCURRENCES OF E STABILITY - 5408

NUMBER OF CALMS WITH E STABILITY - 0

Table II-15

ANNUAL CLASS F STABILITY FREQUENCY DISTRIBUTION, HOBBS, NEW MEXICO, 1949, 1953, 1954
SPEED (KNOTS)

Direction	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	Greater Than 21	AVG SPD	TOTAL
N	84	101	0	0	0	0	3.9	185
NNE	29	32	0	0	0	0	3.9	61
NE	63	89	0	0	0	0	4.0	152
ENE	26	17	0	0	0	0	3.7	43
E	88	97	0	0	0	0	3.8	185
ESE	38	74	0	0	0	0	4.2	112
SE	176	246	0	0	0	0	4.0	422
SSE	31	79	0	0	0	0	4.2	110
S	125	270	0	0	0	0	4.3	395
SSW	53	117	0	0	0	0	4.4	170
SW	109	216	0	0	0	0	4.3	325
WSW	31	52	0	0	0	0	4.2	83
W	46	71	0	0	0	0	4.1	117
WNW	37	41	0	0	0	0	3.9	78
NW	87	155	0	0	0	0	4.2	242
NNW	21	42	0	0	0	0	4.1	63
AVG	2.8	5.0	0.0	0.0	0.0	0.0	3.7	
TOTAL	1044	1699	0	0	0	0		

NUMBER OF OCCURRENCES OF F STABILITY - 3096

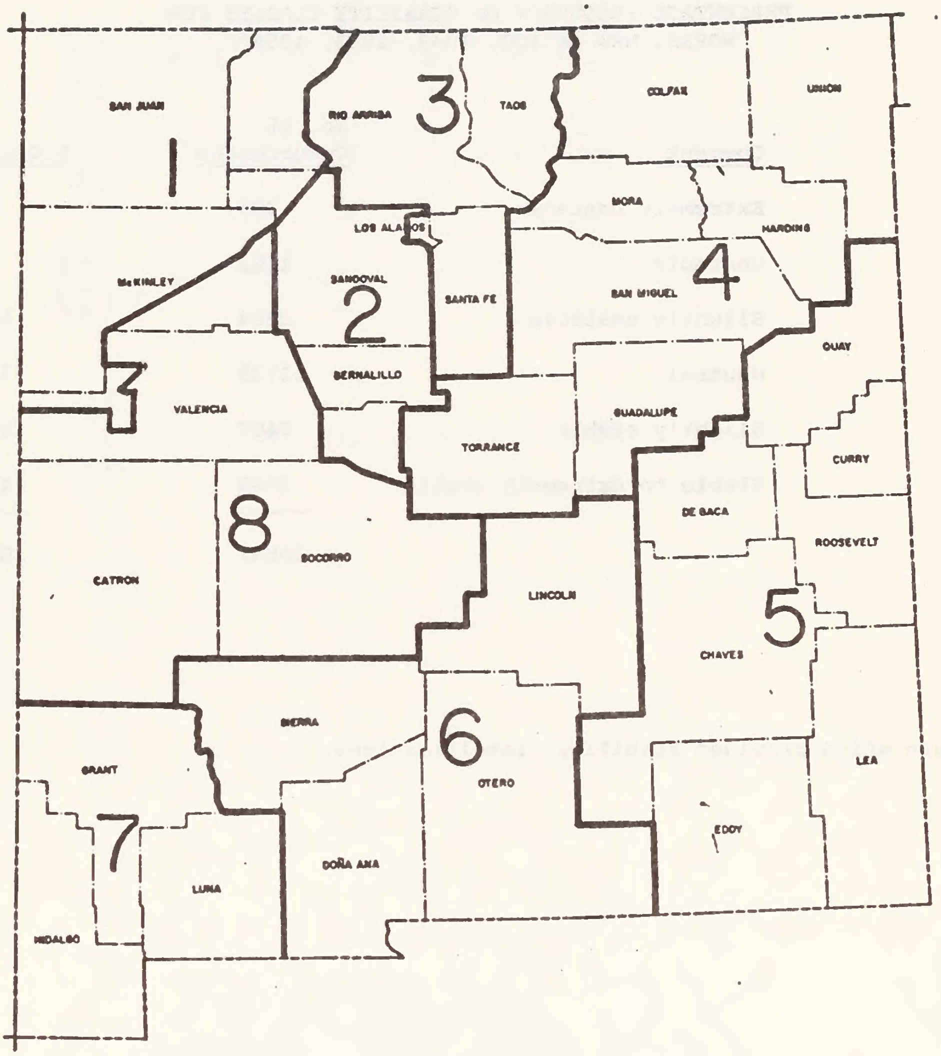
NUMBER OF CALMS WITH F STABILITY - 353

Table II-16

PERCENTAGE FREQUENCY OF STABILITY CLASSES FOR HOBBS, NEW MEXICO, 1949, 1953, 1954*

Class	Comment	No. of Occurrences	% Occurrence
A	Extremely unstable	285	1.1
B	Unstable	1162	4.3
C	Slightly unstable	2804	10.5
D	Neutral	13723	51.1
E	Slightly stable	5408	20.2
F	Stable to extremely stable	3449	12.8
		26831	100.0

*Only data which provides stability classifications.



1 — FOUR CORNERS INTERSTATE (ARIZONA-COLORADO-NEW MEXICO-UTAH)
2 — ALBUQUERQUE-MID RIO GRANDE INTRASTATE
3 — UPPER RIO GRANDE VALLEY INTRASTATE
4 — NORTHEASTERN PLAINS INTRASTATE
5 — PECOS-PERMIAN BASIN INTRASTATE
6 — EL PASO-LAS CRUCES-ALAMOGORDO INTERSTATE (NEW MEXICO-TEXAS)
7 — ARIZONA-NEW MEXICO SOUTHERN BORDER INTERSTATE
8 — SOUTHWESTERN MOUNTAINS-AUGUSTINE PLAINS INTRASTATE

FIGURE II-1: Air Quality Control Regions in New Mexico

TABLE II-17

AMBIENT AIR QUALITY IN PECOS - PERMIAN BASIN
AIR QUALITY CONTROL REGION 5 - NEW MEXICO

Station Location and Address	County	Station Type	Sampler Height Above Ground (f+)	Sampling Period Year	Sampling Period Quarter	Particulates[a] No. of observations	Particulates[a] Range (ug/m^3)[c]	Particulates[a] Geometric Mean (ug/m^3)	Sulfur Dioxide[b] No. of observations	Sulfur Dioxide[b] Range	Sulfur Dioxide[b] Arithmetic Mean (ug/m^3)	Nitrogen Dioxide No. of observations (April - Dec., 1974)	Nitrogen Dioxide Range	Arithmetic Mean (ppm)
Artesia 800 So. Roselawn St.	Eddy	Suburban-Industrial	25	1972	3	8	28-472	48						
				1972	4	11	18- 48	31						
				1973	1	2	21- 39		3	2 - 2	2			
				1974	1	3	35- 98							
				1974	2	15	36- 92	62	7	2 -21	6	18	0.009-0.027	0.017
Carlsbad County Court-house	Eddy	Center City-Comercial	40	1971	1	2	77- 77							
				1971	2	9	45-105	72						
				1971	3	11	42-100	68						
				1972	1	13	49-160	86						
				1972	2	10	48-128	68						
				1972	3	12	28-275	53						
				1972	4	9	23- 89	41						
				1973	1	10	13- 66	40	9	2 - 2	2			
				1973	2	5	30- 59	44	9	2 - 5	3			
				1973	3	4	19- 50		5	2 - 2	2			
				1974	1	3	64- 86							
				1974	2	14	40-111	63	12	2 - 5	3	16	0.002-0.037	0.016
Clovis 320 Mitchell	Curry	Suburban-Commercial	25	1970	1	12	28-155	60						
				1970	2	13	37-485	90						
				1970	3	13	42-196	80						
				1970	4	13	17-119	72						
				1971	1	7	58-188	108						
				1971	2	14	61-154	96						
				1971	3	4	46- 89							
				1971	4	3	46- 98							
				1972	1	6	61-159	97						
				1972	2	6	57-155	102						
				1972	3	8	66-160	99						
				1973	1	1	13							
				1973	2	6	14-129	54						
				1974	1	1	47							
				1974	2	7	59-101	81						
Eunice Police Dept.	Lea	Center City-Residential	50	1973	1	4	16- 26							
				1974	2	5	43- 98		7	2 -21	5			
Hobbs 1701 No. Turner	Lea	Suburban-Residential	25	1970	1	12	28-120	51						
				1970	2	11	34-147	64						
				1970	4	2	46- 59							
				1972	1	1	123							
				1972	2	5	43- 79							
				1972	3	5	18-283	44						
				1972	4	2	50-171							
				1973	1	5	13- 58	33						
				1973	2	2	31- 37							
				1974	1	2	10- 51							
				1974	2	15	10-184	53	5	2 -13	7			
Jal Jal High School	Lea	Suburban-Residential	15	1974	2	13	40-230	63	11	2 -21	5			
Cooper Ranch (30 miles east of Potash area)	Lea	Remote	10	1973	1	1	81							
				1973	2	1	47							
				1973	4	3	93-282							
				1974	1	14	31-241	110				19	0.000-0.040	0.016
				1974	2	15	55-366	113	8	2 -52	9			
Lovington 302 No. 5th.	Lea	Suburban-Commercial	15	1973	1	6	16- 95	34						
				1974	2	5	54- 85							
Roswell 500 No. Main	Chaves	Center City-Commercial	100	1971	1	3	37- 75							
				1971	2	7	84-211	115						
				1972	1	8	44- 80	63						
				1972	2	12	25-632	74						
				1972	3	3	39-507							
				1973	1	4	15- 43							
				1973	2	4	19- 52							
				1974	1	2	48- 55							
				1974	2	11	31- 87	54	2	2 - 3	2			
Tucumcari Courthouse	Quay	Center City-Commercial	20	1974	1	1	91							
				1974	2	10	21- 78	37						
Smith Ranch Approximately 3.5 miles east of IMC refinery	Eddy	Remote	?	1974	4	13	15 -133	37						

a = particulates measured by gravimetric technique following sample collection with high-volume sampler for 24-hour period.

b = sulfur dioxide measured by pararosaniline-sulfamic acid method following sample collection with gas bubbler for 24-hour period.

*[c] ug/m^3: micrograms per cubic meter

From National Aerometric Data Bank of the Environmental Protection Agency

Table II-18

NEW MEXICO AMBIENT AIR QUALITY STANDARDS

201. Ambient Air Quality Standards

A. The maximum allowable concentrations of total suspended particulate in the ambient air are as follows:

		Maximum Concentration
1.	24-hour average	150 ug/m^3
2.	7-day average	110 ug/m^3
3.	30-day average	90 ug/m^3
4.	annual geometric mean	60 ug/m^3

B. When one or more of the following elements are present in the total suspended particulate, the maximum allowable concentrations of the elements involved, based on a thirty-day average, are as follows:

		Maximum Concentration
1.	beryllium	0.01 ug/m^3
2.	asbestos	0.01 ug/m^3
3.	heavy metals (total combined)	10 ug/m^3

C. The maximum allowable concentrations of the following air contaminants in the ambient air are as follows:

		Maximum Concentration
1.	sulfur dioxide	
	(a) 24-hour average	0.10 ppm*
	(b) annual arithmetic average	0.02 ppm
2.	hydrogen sulfide	
	(a) for the state, except the Pecos-Permian Basin Intrastate Air Quality Control Region (1-hour average)	0.003 ppm
	(b) for the Pecos-Permain Basin Intrastate Air Quality Control Region (½-hour average)	0.100 ppm
	(c) after January 1, 1976, for within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region (½-hour average	0.030 ppm
	(d) after January 1, 1978, for within five miles of the corporate limits of municipalities having a population of greater than twenty thousand and within the Pecos-Permian Basin Intrastate Air Quality Control Region (½-hour average)	0.030 ppm

Table II-18 continued

3. total reduced sulfur	
(a) for the state except the Pecos-Permian Basin Intrastate Air Quality Control Region, including hydrogen sulfide (1-hour average)	0.003 ppm
(b) for the Pecos-Permian Basin Intrastate Air Quality Control Region, except for hydrogen sulfide (½-hour average)	0.010 ppm
(c) after January 1, 1976, for within corporate limits of municipalities within the Pecos-Permian Basin Intrastate Air Quality Control Region, except for hydrogen sulfide (½-hour average)	0.003 ppm
(d) after January 1, 1978, for within five miles of the corporate limits of municipalities having a population of greater than twenty thousand and within the Pecos-Permian Basin Intrastate Air Quality Control Region, except hydrogen sulfide (½-hour average)	0.003 ppm
4. Carbon monoxide	
(a) 8-hour average	8.7 ppm
(b) 1-hour average	13.1 ppm
5. Nitrogen dioxide	
(a) 24-hour average	0.10 ppm
(b) annual arithmetic average	0.05 ppm
6. Photochemical oxidants (1-hour average)	0.06 ppm
7. Non-methane hydrocarbons (3-hour average)	0.19 ppm

D. On an annual average, the soiling index shall not exceed 0.4 cohs*/1000 linear feet of air.

*ppm: parts per million

*cohs: coefficient of haze, the quantity of light scattering solids capable of producing an optical density of 0.01 when the amount of light transmitted through the spot of dust collected on the tape of a smoke sampler is measured in a suitable densitometer.

From Section Number 201 of the Ambient Air Quality Standards and Air Quality Control Regulations adopted by the New Mexico Health and Social Services Board on January 23, 1970, as amended.

Table II-19 Federal Primary and Secondary Air Quality Standards

All measurements are expressed in micrograms per cubic meter (ug/m^3) except for those for carbon monoxide, which are expressed in milligrams per cubic meter (mg/m^3). Equivalent measurements in parts per million (ppm) are given for the gaseous pollutants.

Pollutant	Primary	Secondary
Particulate Matter		
Annual geometric mean	75	60
Maximum 24-hour concentration*	260	150
Sulfur Oxides		
Annual arithmetic mean	80 (.03 ppm)	60 (.02 ppm)
Maximum 24-hour concentration*	365 (.14 ppm)	260 (.1 ppm)
Maximum 3-hour concentration*		1,300 (.5 ppm)
Carbon Monoxide		
Maximum 8-hour concentration*	10 (9 ppm)	
Maximum 1-hour concentration*	40 (35 ppm)	same as primary
Photochemical Oxidants		
Maximum 1-hour concentration*	160 (.08 ppm)	same as primary
Hydrocarbons		
Maximum 3-hour (6-9 am) concentration*	160 (.24 ppm)	same as primary
Nitrogen Oxides		
Annual arithmetic mean	100 (.05 ppm)	same as primary

* Not to be exceeded more than once a year.

Primary: Levels of air quality necessary to protect the public health with an adequate margin of safety.

Secondary: Levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

Table II-20 Summary of Ambient Air Quality in Pecos-Permian Basin in Relation to Air Quality Standards

a = nos. in () represent no. of measurements.

* = exceeds New Mexico standard

b = not sufficient measurements to allow calculation of mean.

		Particulate (Ug/M^3)		Sulfur Dioxide (Ug/M^3)		Nitrogen Dioxide (ppm)	
Station	Year	Annual Geometric Mean	Maximum 24-Hour Concentration	Annual Arithmetic Average	Maximum 24-Hour Concentration	Annual Arithmetic Average	Maximum 24-Hour Concentration
Artesia	1972	40 (19)[a]	472*				
	1973	b	39	2 (3)	2		
	1974	62* (15)	98	6 (7)	21	0.017 (16)	0.027
Carlsbad	1971	70* (20)	105				
	1972	62* (44)	275*				
	1973	42 (15)	66	2 (23)	5		
	1974	63* (14)	111	3 (12)	5	0.016 (16)	0.037
Clovis	1970	76* (51)	485*				
	1971	102* (21)	188*				
	1972	99* (20)	160*				
	1973	54 (6)	129				
	1974	81* (7)	101				
Eunice	1974	b	98	5 (7)	21		
Hobbs	1970	58 (23)	147				
	1972	44 (5)	283*				
	1973	33 (5)	58				
	1974	53 (15)	184*	7 (5)	13		
Jal	1974	63* (13)	230*	5 (11)	21		

TABLE II-20 continued

a = nos. in () represent no. of measurements.

* = exceeds New Mexico standard

b = not sufficient measurements to allow calculation of mean.

		Particulate (Mg/M^3)		Sulfur Dioxide (Mg/M^3)		Nitrogen Dioxide (ppm)	
Station	Year	Annual Geometric Mean	Maximum 24-Hour Concentration	Annual Arithmetic Average	Maximum 24-Hour Concentration	Annual Arithmetic Average	Maximum 24-Hour Concentration
Cooper Ranch	1973	b	282*				
	1974	112* (29)	366*	9 (8)	52	0.016 (19)	0.040
Lovington	1973	34 (6)	95				
	1974	b	85				
Roswell	1971	115* (7)	211*				
	1972	68* (20)	632*				
	1973	b	52				
	1974	54 (11)	87	2 (2)	3		
Smith Ranch	1974	37 (13)	133				

area which, due to current air quality or projected growth, has the potential for exceeding a national ambient air quality standard within 10 years from the date of its designation as a maintenance area.

(d) Air Emissions from Potash Industry

The primary air pollutant emissions from the 7 potash refineries are dusts (particulate). (See Photo II-1). In a 1972 study by Duran (1972), is was indicated that the type of emissions associated with 5 out of the 7 potash refineries is primarily potassium chloride dust. (KCl) Duval Corporation and International Minerals & Chemical Corporation, in addition to the KCl dust, also emit certain quantities of langbeinite dust and potassium sulfate dust. There are various sources where the dust is emitted during the processing of the potash, and they can generally be classified in the areas of drying, screening, crushing and grinding, compaction, and evaporation.

(1) Drying

The majority of the emissions come from the drying of the potash. As the material tumbles down the rotary dryers, the fine particles become airborne and are exhausted out of the dryers into cyclone dust collectors. In the cyclone, the particulate laden gas is caused to swirl in the cylinder and cone by admitting it axially or tangentially. The gas proceeds downward to the apex of the cone, forms another spiral upward within the downward spiral and then to the outlet. Particles are separated from the gas stream by means of the centrifugal force created in the vortex flow, and are driven in the direction of the wall of the cyclone body. The cyclones are highly efficient for removing the larger particles, but the smaller particles remain in the gas stream and are exhausted out of the stacks.

(2) Screening

The emissions here are the result of mechanical vibration of the potash material in the process of achieving particle size separation. The majority of the airborne dust is directed into cyclone dust collectors where the large particles are collected and the smaller particles remain in the gas stream and are exhausted into the atmosphere. Some of the material remains in the screening area as fugitive dust which can work its way out of the

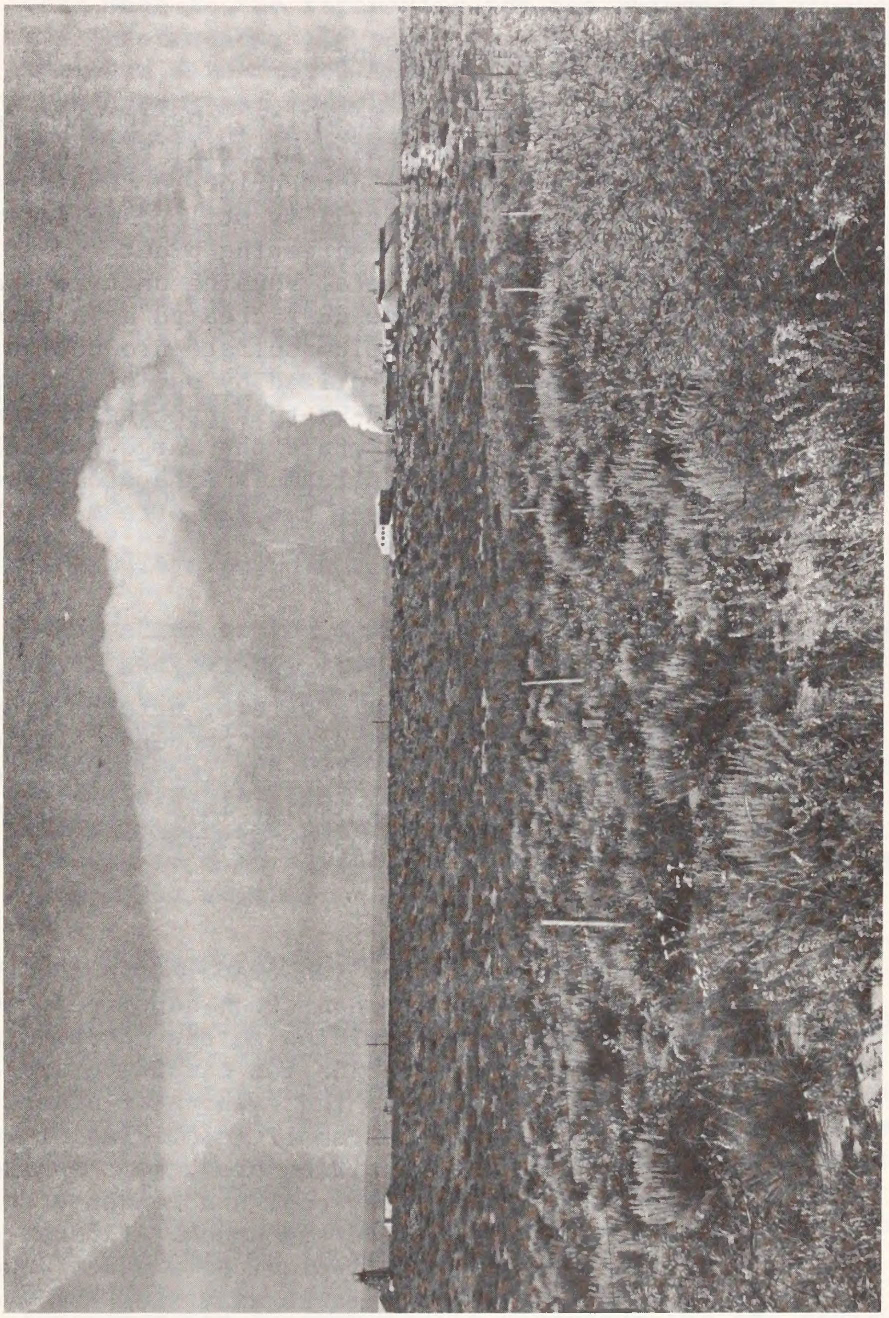


PHOTO II-1 International Minerals Corporation
One mile north of refinery

building through windows, doors, and other openings. This dust residue collected in refinery cyclones is compacted and converted into sylvite product or added to brine.

(3) Crushing and Grinding

In order to obtain the granular, coarse and standard product sizes, the oversize material has to be crushed. Some of the crushing is done prior to the processing of the ore, while the material is still damp and other crushing is done in the screening plant. Most crushers are enclosed within a metal housing unit so that there is little or no fugitive dust created as a result of the crushing. In potassium sulfate production, the langbeinite must be pulverized by use of the Raymond mills. The dust created by this process is sent through cyclone dust collectors where the large particles are removed before the gas stream is exhausted into the atmosphere. In some cases the gas stream may be bled directly into the atmosphere.

(4) Compaction

The dust created here is a result of the fine material being compressed into thin waters, before being broken and resized through a screening process. Again, the dust laden airstream is directed into a cyclone dust collector, where large material is collected before the gas stream is vented into the atmosphere.

(5) Evaporation

The emissions created by the evaporators are the most visible emissions. The heat from submerged combustion of natural gas is transmitted to the surrounding brine by the ascending combustion gas causing evaporation of water. Hot gas going up the evaporator stack contains the evaporated water and small quantities of entrained brine and brine decomposition products. As the gases travel up the stack, they cool and condense, creating a dense plume as they leave the stack. At first glance, the plume appears to be typical of a water condensate plume; but as the plume moves away from the stack, it does not dissipate as quickly as water condensate normally does on a warm day. Although the emissions in terms of quantity do not appear to be much, they consist of very fine particles which apparently cling to the water molecules to cause this effect.

In order to determine the total quantities of the air pollutant emissions from the potash refineries, visits were made to the refineries for the purpose of procuring the information. In addition, data from the National Emission Data System (NEDS) of the Environmental Protection Agency was searched. Table II-21 summarizes the two sources of information for the AMAX refinery, with the NEDS data in the left two columns, and the site visit date (referred to as computer input data source) in the right two columns. The site visit data for AMAX indicated annual emissions of 2629 tons of particulate, while the NEDS indicated 1200 tons. This is probably a result of a mistake in the NEDS system since Tables II-22 through II-27 indicate that the NEDS data and site visit data are in agreement. Table II-28 summarizes the results of the 2 approaches. The computer analysis discussed later utilized 69 sources from the 7 refineries and 19,908 tons/year of particulate emissions. In contrast, Duran (1972) reported on 64 sources and particulate emissions of 20,800 tons/year.

Information on the size and chemical composition of the particles emitted from the refinery stacks is not extensive. Preliminary data is shown in Table II-29 for a dryer stack, and in Table II-30 for an Ozark evaporator. The chemical composition of the dryer dust shown in Table II-29 indicates that potassium and chloride are the major elements. AMAX has reported that up to 0.46 ton/day of hydrogen chloride is emitted from dryer stacks.

(e) Emission Inventory

An emission inventory can be defined as the compilation of the quantities of air pollutants from all sources in a defined area entering the air in a given time period. The time period that is typically utilized in an emission inventory is one year, and the areas are usually associated with a state, county or perhaps with a multi-county region. It should be noted that emission inventory information is useful for general air quality management and trend analysis. It does not include consideration of atmospheric reactions and the damage associated with a given weight of pollutant.

Table II-21: Particulate Emissions from the AMAX Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
1	96	# 1 Dryer 2 Stacks	204
1	96		
3	305	# 2 Dryer Stack	386
5	500	# 1, 2, 3, Compactor Stack	530
6	200	# 4 Compactor Stack	256
9	<1	Product Screening 6 Stacks	1,252.8
10	<1		2,628.8
11	<1		
	1,200		

From National Emission Data System (NEDS)

Table II-22: Particulate Emissions from the Mississippi Chemical Corporation Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
None Listed		# 1 Dryer Stack	464

From National Emission Data System (NEDS)

Table II-23: Particulate Emissions from the Potash Company of America Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
1	14	3 Standard Product Dryers	1005
3	100	2 Granular Dryers	444
4	2700	2 Chemical Product Dryers	800
5	360		
6	10	Soluble Product	450
7	900	5.	360
	4084	6.	10
		7.	900
		8.	100
			4069

From National Emission Data System (NEDS)

Table II-24: Particulate Emissions from the International Minerals Corporation Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
2	2500	9 Ozark Evap.	2448
3	525	Dryer Muriate	525
4	525	Dryer Muriate	525
5	1500	Dryer Muriate	1500
6	1200	Langbeinite Dryer	1200
7	500	Langbeinite Dryer	500
8	2000	Sulphate Dryer	2000
9	800	4 Raymond Mill Crushers	800
12	10		
13	2		
	9562		9498

From National Emission Data System (NEDS)

Table II-25: Particulate Emissions from the Duval Corporation Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
1	350	SAME AS NEDS	
2	350		
3	182		
4	113		
5	200		
6	117		
7	383		
8	123		
9	123		
11	274		
12	350		
13	90		2,655
17	< 1		
18	< 1		
19	< 1		
20	< 1		
21	< 1		
	2,660		

From National Emission Data System (NEDS)

Table II-26: Particulate Emissions from the National Potash Corporation Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
1	2	SAME AS NEDS	
2	1		
3	31		
4	38		
5	10		
6	10		
7	5		
8	31		
	128		

From National Emission Data System (NEDS)

Table II-27: Particulate Emissions from the Kerr-McGee Chemical Corporation Potash Refinery

NEDS Data Source	Emission Strength Tons/year	Computer Input Data Source	Emission Strength Tons/year
1	3	1.	3
2	3	2.	3
3	3	3.	3
4	5	5.	34
5	34	6.	400
6	400	7.	22
7	22		465
	470		

From National Emission Data System (NEDS)

Table II-28: Composite of Air Emissions from Potash Refineries in Carlsbad Area

Company	NEDS Total Tons/yr.	Computer Input Total Tons/yr.	# Part. Sources NEDS	# Part. Sources Computer Input
MCC	464	464	1	1
PCA	4084	4069	6	12
IMC	9562	9498	10	19
Duval	2660	2655	17	12
AMAX	1200	2628.8	8	11
NPC	128	128	8	8
Kerr-McGee	470	465	7	6
TOTAL	18,568	19,907.8	57	69

From National Emission Data System (NEDS)

TABLE II-29

PRELIMINARY SIZE DISTRIBUTION ESTIMATE

NO. 1 MURIATE DRYER STACK

PARTICULATE EMISSIONS

MESH*	% CUM by WT.
100	0.94
150	3.60
200	12.38
325	28.27
400	34.69
-400	65.31

CHEMICAL COMPOSITION OF PARTICULATE SOLIDS

ion	K	Mg	Ca	Cl	SO_4	Insol
%	34.17	2.35	0.26	39.00	10.40	2.54

*Tyler Mesh No.

From International Minerals Corporation Refinery Records, 1975

TABLE II-30

TYPICAL OZARK EVAPORATOR EMISSIONS

STACK GAS PARTICULATE SIZE DISTRIBUTIONS

Particle Diameter (Microns)	% F	% Cum
-7.00 to +2.29	10.3	10.3
-2.29 to +1.38	8.7	19.0
-1.38 to +0.96	14.1	33.1
-0.96 to +0.53	21.0	54.1
-0.53 to +0.35	23.2	77.3
-0.35	22.7	100

Stack Volumetric Rate	10,000 acfm*
Stack Gas Moisture Content	50% by Volume
Stack Gas Particulate Loading	6783 mg/m^3

*actual cubic feet per minute

Data provided to International Minerals Corporation by Monsanto Envirochem. (From International Minerals Corporation Refinery Records, 1975)

Table II-31 shows the total particulate emissions from both area and point sources for the 8 air quality control regions of New Mexico in 1970. Since the estimated potash emissions are 19,997 tons/year (NEDS), this constitutes 97 percent of the Region 5 point source emissions, and 13 percent of the statewide point source emissions. In the same context, the potash industry contributes 28 percent of the combined total of area and point emissions in Region 5 and 5 percent of the combined total area and point source in New Mexico. Calculated on a daily basis, this computes to approximately 55 tons of particulates per day from the potash refineries.

Particulate emissions from area sources such as unpaved roads are a major source of particulate emissions in New Mexico. The particulate emissions from unpaved roads in each Region are shown in Table II-32.

The complete emission inventory for Region 5 is shown in Table II-33. The emissions in this region in 1970 totaled 397,049 tons. The pollutants in the region, arranged according to their tonnage basis, are carbon monoxide (168,815 tons, or 42.5% of the total), oxides of nitrogen (92,428 tons or 23.3%), particulates (70,929 tons or 17.9%), hydrocarbons (35,101 tons or 8.8%), and oxides of sulfur (29,776 tons or 7.5%).

Table II-33 also shows that point sources accounted for 173,047 tons of the total Region 5 emissions in 1970. Therefore, point sources accounted for 43.6 percent of the total, and area sources accounted for 56.4 percent. The percentage contribution of point versus area sources varied for each pollutant as follows:

Particulates --- 29.2 percent from point sources and 70.8 percent from area sources.

Oxides of sulfur (SO_2) --- 94.6 percent from point sources and 5.4 percent from area sources.

Carbon monoxide (CO) --- 25.5 percent from point sources and 74.5 percent from area sources.

Hydrocarbons --- 29.6 percent from point sources and 70.4 percent from area sources.

Oxides of nitrogen (NO_x) --- 76.5 percent from point sources and 23.5 percent from area sources.

TableII-31; New Mexico Particulate Emissions

Region	Particulate Emissions (tons/year)		
	Area	Point	Total
1	28,130	97,089	125,219
2	1,766	232	1,998
3	25,720	25,652	51,372
4	24,971	4,338	29,309
5	50,251	20,678	70,929
6	28,894	457	29,351
7	19,656	4,598	24,254
8	35,134	600	35,734
	214,522	153,644	368,166

From State of New Mexico Implementation Plan for Federal Primary and Secondary Ambient Air Standards, January, 1972.

Table II-32: Contribution of Unpaved Roads to Particulate Emissions in New Mexico

Region	Particulate Emissions from Unpaved Roads (%)
1	21
2	81
3	46
4	82
5	68
6	94
7	78
8	95

From State of New Mexico Implementation Plan for Federal Primary and Secondary Ambient Air Standards, January, 1972.

TABLE II-33

EMISSIONS INVENTORY SUMMARY
STATE OF NEW MEXICO - AIR QUALITY CONTROL REGION 5 - CALENDAR YEAR 1970

SOURCE CATEGORY	TONS OF POLLUTANT/YEAR					FUEL ETC.	
	PART	SO_3	CO	HC	NO_x	QUANTITY	UNITS
I. FUEL COMBUSTION							
A. RESIDENTIAL FUEL-AREA SOURCE							
1. (ANTHRACITE) COAL	4	2	4	1	0	170	Tons
2. DISTILLATE OIL	10	14	5	3	12	1952	10^3 Gal.
3. NATURAL GAS	78	2	821	33	308	8205	MMCF
4. WOOD	39	2	3	3	14	2862	Tons
5. LPG	117	1	2	273	818	38947	10^3 Gal.
6. TOTAL	248	21	96	313	1152		Tons
B. COMM-INSTL & IND							
1a. (BITUMINOUS) COAL-AREA SOURCE	0	0	0	0	0	0	Tons
b. (BITUMINOUS COAL-POINT SOU.	0	0	0	0	0	0	Tons
2. COKE-POINT SOURCE	0	0	0	0	0	0	Tons
3a. DISTILLATE OIL-AREA SOURCE	138	358	1	28	552	18402	10^3 Gal.
b. DISTILLATE OIL-POINT SOURCE	0	0	0	0	0	2	10^3 Gal.
4a. RESIDUAL OIL-AREA SOURCE	0	0	0	0	0	6	10^3 Gal.
b. RESIDUAL OIL-POINT SOURCE	0	0	0	0	0	0	10^3 Gal.
5a. NATURAL GAS-AREA SOURCE	35	1	37	15	138	3637	MMCF
b. NATURAL GAS-POINT SOURCE	341	12	10	813	64513	50033	MMCF
6. PROCESS GAS-POINT SOURCE	0	0	0	0	0	0	MMCF
7a. WOOD-AREA SOURCE	0	0	0	0	0	0	Tons
b. WOOD-POINT SOURCE	0	0	0	0	0	0	Tons
8a. OTHER	285	747	40000	4843	1424	0	MMCF
b. OTHER	0	0	0	0	0	0	
9. TOTAL	799	1179	40048	6012	66627		Tons
C. STEAM-ELECTRIC POWER PLANT							
1. ANTHRACITE COAL	0	0	0	0	0	0	Tons
2. BITUMINOUS COAL	0	0	0	0	0	0	Tons
3. DISTILLATE OIL	2	0	0	0	9	300	10^3 Gal.
4. RESIDUAL OIL	0	0	0	0	0	0	10^3 Gal.
5. NATURAL GAS	153	6	3	407	3975	20382	MMCF
6. OTHER	0	0	0	0	0	0	
7. TOTAL	155	6	3	407	3984		Tons
D. TOTAL FUEL COMBUSTION	1202	1195	40147	6419	71763		Tons
II. PROCESS LOSSES							
A. AREA SOURCES	0	0	0	282	0		Tons
B. POINT SOURCES	19714	21336	1979	4006	723		Tons
III. SOLID WASTE DISPOSAL							
A. INCINERATION							
1a. ON SITE-AREA SOURCE	0	0	0	0	0	5	Tons
b. ON SITE-POINT SOURCE	11	0	195	17	2	3256	Tons
2. MUNICIPAL ETC.-POINT SOURCE	0	0	0	0	0	0	Tons
B. OPEN BURNING							
1a. ON SITE-AREA SOURCE	217	14	1153	407	81	27123	Tons
b. ON SITE-POINT SOURCE	0	0	0	0	0	0	Tons
2a. DUMPS-AREA SOURCE	0	0	0	0	0	0	Tons
b. DUMPS-POINT SOURCE	172	9	901	317	62	21176	Tons
C.1. OTHER	0	0	0	0	0	0	
2. OTHER	0	0	0	0	0	0	
D. TOTAL SOLID WASTE DISPOSAL	400	23	2249	741	145		Tons
IV. TRANSPORTATION AREA SOURCE							
A1. MOTOR VEHICLES-GASOLINE	480	290	120948	21402	16704	1452700	10^3 Veh-mile
2. MOTOR VEHICLES - DIESEL	162	327	2361	472	2470	14523	10^3 Gal.
B. OFF HIGHWAY FUEL USAGE	0	0	0	0	0	0	
C. AIRCRAFT ----------------------	133	88	591	225	88		
D. RAILROAD -----------------------	180	467	503	360	529	14384	10^3 Gal.
E. VESSELS-------------------------	0	0	0	0	0	0	
F. GASOLINE HNDLG EVAP. LOSSES----	0	0	0	1202	0	114466	10^3 Gal.
G. UNPAVED ROADS-------------------	48628	0	0	0	0	104184	10^3 Veh-mile
H. TOTAL TRANSPORTATION ----------	50503	1172	12440	23662	19786		Tons
V. MISCELLANEOUS AREA SOURCES -----							
A. AGRICULTURAL BURNING ----------	10	0	37	1	1		
B. OTHER--------------------------	0	0	0	0	0	0	
C. TOTAL MISCELLANEOUS -----------	10	0	37	1	1		
VI. GRAND TOTAL							
A. AREA SOURCE -------------------	50251	1608	125727	24708	21720		Tons
B. POINT SOURCE ------------------	20673	28170	43088	10403	70708		Tons
C. TOTAL	70929	29778	168815	35111	92428		Tons

Based on the State Implementation Plan which was published in January, 1972, (State of New Mexico) the Pecos-Permian Basin Region was classified as Priority III for all 6 pollutants for which Federal ambient air standards had been promulgated. Table II-34 summarizes this classification for New Mexico. Priority I means that air quality standards are exceeded, Priority IA designates regions with unique point sources, Priority II means that the existing air quality is close to standards, and Priority III means that standards are met, and that measures should be taken to preserve and enhance the present air quality. Actually, based on monitoring data collected since 1970, and summarized in Table II-20, p. 28, the priority classification for particulates should be either I or II.

In order to present emission inventory data for the potash refineries, the 1972 NEDS data is summarized in Tables II-35 through II-41 for the 7 refineries Table II-42 contains a summary of the emissions inventories for the potash refineries and the Region. The potash industry is a major contributor of particulates, and only a minimal contributor of other air pollutants such as CO, NO_x, SO_2, and hydrocarbons.

Table II-43 shows the emissions of pollutants expressed on a product basis, i.e., lb. of pollutant per ton of finished potash product. These values are based on 1974 production figures. The range of factors for particulates indicates the influence of refinery age and process technology.

In order to control the output of particulate emissions into the atmosphere, dust collection equipment is utilized by the potash industry. Table II-44 summarizes the air pollution control equipment in use in 1975. Out of 69 point sources in the 7 refineries, 42 (61%) have particulate control devices. The predominant type of collector is the high-efficiency centrifugal collector, or cyclone. High-efficiency refers to removals in the order of 95%. Duran (1972) suggested that the best method to control the emissions from the various stages of processing, with the exception of the evaporation, is by the use of wet scrubbers. Since most of the potassium salts are soluble in water, a saturated brine solution would probably be more suitable for collection of the particles. Duran also suggested that the use of bag collectors is questionable, since the potassium particles are hygroscopic (take up and retain moisture) and have a tendency to cake and clog the bags.

TableII-34; Air Quality Regional Classifications for New Mexico, January 1972

AQCR	Particulates	SO_2	CO	NO_2	HC (OX)
7-Arizona - New Mexico Southern Border Interstate	IA	IA	III	III	III
6-El Paso - Las Cruces - Alamogordo Interstate	I	I	I	III	I
1-Four Corners Interstate	IA	IA	III	IA	III
2-Albuquerque - Mid Rio Grande	I	III	III	III	I
4-Northeastern Plains	III	III	III	III	III
5-Pecos - Permian Basin	III	III	III	III	III
8-Southwestern Mountains - Augustine Plains	III	III	III	III	III
3-Upper Rio Grande Valley	III	III	III	III	III

Table II-35: Emission Inventory for Mississippi Chemical Corporation Potash Refinery

Year of Record: 1975

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year Part.	SO X	NO X	HC	CO
1	No Control Equipment		1	464				
TOTAL				464				

Table II-36: Emission Inventory for Potash Company of America Potash Refinery

Year of Record: 1972

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year Part.	SO X	NO X	HC	CO
1			3	14	<1	173	2	13
2			3			154		
3	Centrifugal Collector Medium Efficiency		2	100				
4	"		1	2700				
5	"		2	360				
6	"		2	10				
7			2	900				
TOTAL				4084	<1	327	2	13

Table II-37: Emission Inventory for International Minerals Corporation Potash Refinery

Year of Record: 1972

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year Part	SO X	NO X	HC	CO
1			3					
2			1	2500				
3	Centrifugal Collector Medium Efficiency	90%	2	525				
4	"	"	2	525				
5	"	"	1	1500				
6	"	"	1	1200				
7	"	"	2	500				
8	"	"	1	2000				
9	"	"	1	800				
10	"	80%	3					
11			3					
12			3	10	< 1	125	2	9
13			3	2	< 1	29	< 1	2
TOTAL				9562	< 2	154	< 3	11

Table II-38: Emission Inventory for Duval Corporation Potash Refinery

Year of Record: 1972

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year				
				Part.	SO X	NO X	HC	CO
1	Centrifugal Collector High Efficiency		1	350				
2	"		1	350				
3	"		1	182				
4	"		1	113				
5	"		1	200				
6	"		1	117				
7	"		1	383				
8	"		1	123				
9	"		1	123				
10	No Control Equipment		4					
11	"		1	274				
12	Centrifugal Collector High Efficiency		1	350				
13	Wet Scrubber Medium Efficiency	99%	2	90				
14	"	99%	4					
15	"	99%	4					
16	"	99%	4					
17	No Control Equipment		3	<1	<1	3	<1	<1
18	"		3	<1	<1	3	<1	<1
19	"		3	<1	<1	3	<1	<1
20	"		3	<1	<1	2	<1	<1
21	"		3	<1	<1	12	<1	<1
TOTAL				2660	<5	23	<5	<5

Table II-39: Emission Inventory for AMAX Chemical Corporation Potash Refinery

Year of Record: 1972

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year				
				Part.	SO X	NO X	HC	CO
1	Centrifugal Collector High Efficiency	97%	1	96				
2	"	"	1	96				
3	"	"	1	305				
4	"	99%	4					
5	"	95%	1	500				
6	"	98%	1	200				
7	"	97%	4					
8	"	"	4					
9	No Control Equipment		3	<1	<1	4	<1	<1
10	"		3	<1	<1	14	<1	<1
11	"		3	<1	<1	15	<1	<1
TOTAL				1200*	< 3	33	< 3	< 3

* Too low, number should be 2629

Table II-40: Emission Inventory for National Potash Corporation Potash Refinery

Year of Record: 1972

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year				
				Part.	SO_X	NO_X	HC	CO
1	No Control Equipment		3	2	<1	24	<1	2
2	"		3	1	<1	15	<1	1
3	Centrifugal Collector High Efficiency	99%	1	31				
4	"	99%	1	38				
5	"	99%	2	10				
6	"	95%	2	10				
7	"	99%	1	5				
8	No Control Equipment		1	31				
9	"		3					
TOTAL				128	<2	39	<2	3

Table II-41: Emission Inventory for the Kerr-McGee Chemical Corporation
Potash Refinery

Year of Record: 1972

EMISSION QUANTITIES ESTIMATED BY:
1. Stack Test/Measurements
2. Materials Balance
3. Used Emission Factors
4. Guess

Point Source	Control Equipment	Efficiency	Est. By	Emission in Tons Per Year				
				Part.	SO_X	NO_X	HC	CO
1			3	3	<1	40	<1	3
2			3	3	<1	40	<1	3
3			3	3	<1	40	<1	3
4			3	5	<1	60	<1	4
5	Centrifugal Collector High Efficiency	94%	2	34				
6	Wet Scrubber	93%	1	400				
7	Centrifugal Collector High Efficiency	94%	2	22				
TOTAL				470	<4	180	<4	13

Table II-42: Composite of Emission Inventory from Potash Industry Refineries in Carlsbad Area

EMISSION INVENTORY SUMMARY

Potash Sources	Total Emissions Per Plant in Tons Per Year					Percent Each Source Contributes to Total Potash Emissions				
	Part.	SO X	NO X	HC	CO	Part.	SO X	NO X	HC	CO
MCC	464					2.3	0	0	0	0
PCA	4,084	1	327	2	13	20.4	5.9	43.9	10.5	27.0
IMC	9,562	2	154	3	11	47.8	11.7	20.6	15.7	22.9
Duval	2,660	5	12	5	5	13.4	29.4	1.6	26.3	10.4
AMAX	2,629	3	33	3	3	13.1	17.6	4.4	15.7	6.3
NPC	128	2	39	2	3	0.6	11.7	5.2	10.5	6.25
Kerr-McGee	470	4	180	4	13	2.4	23.5	24.1	21.0	27.0
GRAND TOTAL	19,997	17	745	19	48					
Grand Total Area + Point Sources for Regions, 1972	70,929	29,776	92,428	35,101	168,815					
Percent Potash Industry contributes to Reg.5 Emission Inventory	28.2	0.05%	0.8%	0.05%	0.028%					
Point Source Total for Reg.5 1970	20,678	28,170	70,708	10,403	43,088					
Percent Potash Industry contributes to Reg. 5 Point Source Emissions	97.7%	0.06%	1.05%	0.18%	0.11%					

Table II-43: Pollutant Emission Factors for Potash Industry, Carlsbad Area

(pounds of emmission/tons of product)

Plant	Part.	SO X	NO X	HC	CO
MCC	7.73	±0	±0	±0	±0
PCA	9.49	±0	0.76	±0	0.03
IMC	23.90	±0	0.38	±0	0.03
Duval	7.88	0.02	0.07	0.02	0.02
AMAX	7.51	0.01	0.09	0.01	0.01
NPC	0.52	±0	0.16	±0	0.01
Kerr-Mcgee	1.71	0.01	0.65	0.01	0.05

±: approximately

Table II-44: Air Pollution Control Equipment in Use at the Current Time by Potash Industry in Carlsbad Area

Company	Total Number of Point Sources	Total Number of Point Sources with Control Equipment	Number of Sources with Control Equipment by Type of Equipment		
			Centrifugal Collector (Medium Eff.)	Centrifugal Collector (High Eff.)	Wet Scrubber
MCC	1	0			
PCA	7	4	4		
IMC	13	8	8		
Duval	21	14		10	4
AMAX	11	8	8		
NPC	9	5	5		
Kerr-McGee	7	3		2	1
TOTALS	69	42	12	25 ?	5

(f) Air Quality Around the Potash Refineries

The New Mexico EIA does not operate an air sampling network in the vicinity of the potash refineries. Two refineries have conducted ambient air monitoring, AMAX and Duval. Duval's program is just getting underway and will not be summarized. The sampling program at AMAX initiated in 1971, consists of the collection and chemical analysis of total suspended particulates (TSP) and dustfall. A summary of the TSP sampling and analysis is shown in Table II-45. A chemical analysis of the composition of the particulate materials for the first two periods is shown in Table II-46. According to the analysis, the insoluble matter and silicon dioxide content of the samples taken from the laboratory location were considerably higher, on a percentage of total sample basis, than the ones taken from the main office location. Most of this material is sand picked up by the wind and deposited in the sample.

Dustfall data from the AMAX refinery is summarized in Table II-47. The dustfall buckets were placed in the following locations:

No. 1: 1,100 ft. east of dryer stacks

No. 2: 300 ft. from dust fan, north of #2 warehouse

No. 3: at south fence line, 1,000 ft. from ore pile

No. 4: at west fence line, 500 ft. from dust source.

The results of samples from the following periods are contained in Table II-47:

Period No. 1 - April 21, 1972 to July 21, 1972
Period No. 2 - July 24, 1972 to January 24, 1973
Period No. 3 - January 25, 1973 to October 2, 1973.

According to officials of the AMAX Company, the samples from Position 3, Period 3, and Position 4, Period 2 are not valid due to suspected tampering with the contents of the containers. Another point is that the silica content of the fallout material averaged 39.5 percent for the four samples with a high of 45 percent and a low of 25 percent. The inference made is that the sampling was biased by the presence of blow sand in the buckets. The AMAX product contains much less than this quantity of insolubles.

Table II-45: Summary of Amax Sampling for Particulates in the Ambient Air*

Station Location	Period	No. of Samples	Particulate Concentrations (Ug/m^3) Range	Arithmetic Average
No. side of Laboratory	Oct. 6 - Nov. 9, 1971	25	65 - 1913	568
Office near No. side of Entrance gate	Nov. 11, 1971 - April 2, 1972	47	53 - 3603	812
Top of Laboratory Building	Oct. 17, 1972 - Dec. 18, 1972	43	80 - 4262	1334

*These are all located within the refinery site

Data furnished by AMAX Chemical Corporation

Table II-46: Chemical Analysis of Suspended Particulate Samples Collected in the Vicinity of Amax

Composite	Oct.'71	Nov.'71	Jan.'72	Feb.'72	Mar.'72	Apr.'72	Ave.
% K	17.23	20.31	12.43	20.70	20.46	18.70	18.30
% K_2O	20.76	24.47	14.97	24.94	24.65	22.53	22.05
% Ca	0.55	0.77	0.45	0.60	0.54	0.44	0.56
% Mg	0.86	0.78	1.47	1.05	1.33	1.41	1.15
% Na	6.52	6.11	18.72	11.46	14.33	15.67	12.14
% Cl	27.94	30.28	43.12	38.51	43.47	43.83	37.86
% SO_4	1.17	1.61	1.28	2.05	1.51	1.47	1.52
% Br	0.03	0.04	0.03	0.04	0.04	0.04	0.04
% SiO_2	19.87	16.43	5.14	6.22	4.06	3.93	9.28
% Al	1.02	0.85	0.61	1.02	0.63	0.70	0.81
% Al_2O_3	1.92	1.60	1.15	1.92	1.19	1.33	1.52
% Fe	0.54	0.44	0.34	0.40	0.28	0.31	0.38
% FeO_3	0.81	0.65	0.51	0.60	0.42	0.44	0.57
% H_2O Insol.	37.26	31.37	12.96	15.14	8.81	8.86	19.07
% Acid Insol.	24.64	18.42	6.14	8.02	4.78	4.75	11.12
Moisture	8.47	8.77	9.57	10.49	18.36	9.62	10.88

Ether extraction - Hi volume air sampler. Comp. #1 consists of samples dated: 10/6, 10/13, 11/12, 11/15, 1971, total sample weight of 4.7888 grams. Extracted 1.0204 grams of organic material for a value of 21.31%. Comp. #2 composed of samples: 1/26, 1/30, 2/3, 2/22, 1972, total sample weight of 12.5057. Ether extraction produced 0.7457 grams of organic material for a value of 5.96%.

Data furnished by AMAX Chemical Corporation

Table II-47: Analysis of Dustfall Samples from Amax

DUSTFALL CANNISTER NO. 1

	Period No. 1	Period No. 2	Period No. 3
Wt. of Sample	0.6493 g.	1.3308 g.	1.668 g.
Settlable Particles			
g/m_2 per month	11.86	12.16	11.03
% K_2O	13.51	37.40	26.57
% K	11.22	31.05	22.06
% Ca	0.21	1.14	1.77
% Mg	Nil	0.68	0.63
% Na	3.49	4.81	3.57
% Cl	14.33	38.63	28.93
% SO_4	0.83	2.01	2.08
% SiO_2	45.05	7.19	13.19
% Al	0.45	0.61	0.92
% R_2O_3	2.19	1.50	2.47
% Fe	0.94	0.25	0.51
% H_2O Insol.	61.34	13.59	32.20
% Acid Insol.	52.86	10.94	28.01
Moisture	7.35	8.09	8.76

Period No. 1: April 21, 1972 to July 21, 1972
Period No. 2: July 24, 1972 to January 24, 1973
Period No. 3: January 25, 1973 to October 2, 1973

Table II-47 (continued)

DUSTFALL CANNISTER NO. 2

	Period No. 1	Period No.2	Period No.3
Wt. of Sample	1.7350 g.	5.5496 g.	5.2438 g.
Settlable Particles g/m_2 per month	31.71	50.71	34.85
% K_2O	33.00	48.57	38.99
% K	27.39	40.32	32.37
% Ca	0.13	0.48	0.56
% Mg	0.02	0.30	0.26
% Na	3.87	1.61	4.09
% Cl	30.65	40.31	36.61
% SO_4	0.50	0.91	1.06
% SiO_2	24.92	7.75	11.54
% Al	0.30	0.28	0.49
% R_2O_3	1.48	0.77	1.33
% Fe	0.63	0.19	0.28
% H_2O Insol.	32.94	12.07	22.90
% Acid Insol.	28.28	10.19	18.94
Moisture	4.29	4.00	2.15

DUSTFALL CANNISTER NO. 3

	Period No. 1	Period No. 2	Period No. 3
Wt. of Sample	0.7242 g.	2.0861 g.	15.5442 g.
Settlable Particles g/m_2 per month	13.23	19.06	103.29
% K_2O	11.67	25.31	3.77
% K	9.69	21.01	3.13
% Ca	0.23	1.05	0.35
% Mg	0.05	1.01	0.17
% Na	6.80	9.86	1.67
% Cl	18.36	37.73	6.22
% SO_4	2.27	1.87	0.42
% SiO_2	44.50	12.24	40.70
% Al	0.33	0.49	0.65
% R_2O_3	1.62	1.47	2.80
% Fe	0.70	0.39	1.10
% H_2O Insol.	56.09	20.91	87.04
% Acid Insol.	52.36	17.50	82.88
Moisture	6.51	6.56	1.00

Period No. 1: April 21, 1972 to July 21, 1972
Period No. 2: July 24, 1972 to January 24, 1973
Period No. 3: January 25, 1973 to October 2, 1973

Taken from Data Furnished by Amax Chemical Corporation

Table II-47 (continued)

DUSTFALL CANNISTER NO. 4

	Period No. 1	Period No. 2	Period No. 3
Wt. of Sample	1.3876 g.	17.2774 g.	4.0275 g.
Settlable particles			
g/m_2 per month	25.36	157.87	26.76
% K_2O	23.67	55.04	25.80
% K	19.65	45.69	21.42
% Ca	0.10	0.16	0.30
% Mg	0.06	0.39	0.29
% Na	4.76	2.33	14.21
% Cl	24.79	45.76	42.39
% SO_4	0.53	0.59	0.43
% SiO_2	39.47	1.62	6.29
% Al	0.32	0.08	0.28
% R_2O_3	1.28	0.26	0.81
% Fe	0.47	0.08	0.20
% H_2O Insol.	45.95	2.39	10.04
% Acid Insol.	43.09	1.90	8.77
Moisture	3.80	2.69	10.92

Period No. 1: April 21, 1972 to July 21, 1972
Period No. 2: July 24, 1972 to January 24, 1973
Period No. 3: January 25, 1973 to October 2, 1973

Taken from Data Furnished by Amax Chemical Corporation

A preliminary study utilizing the distance from the source, the density of the fallout, and actually cumulating all the tonnages measured, totals 92.3 tons per year fallout in an area 1,100 feet from the source. If the tabulation were made on the basis of the area samples, the fallout tonnage totals 49 tons per year in the 1,100-foot radius of the sample pots.

(g) Calculations for Air Quality Around the Potash Refineries

Predictions of the annual average concentrations of particulate matter in the atmosphere were made through the use of a climatological dispersion model (CDM). The CDM is described in Appendix A-1. In order to utilize the model, meteorological data and specific stack emission information is required. The meteorological data is summarized in Tables II-10 through II-15 (pp.15-21). The input information in terms of stack heights and diameters, gas velocities and temperatures, and emission quantities for the 7 refineries are shown in Appendix A-2.

The computer analyses were conducted for each refinery individually, and for all 7 refineries together. Table II-48summarizes the maximum ground concentration, on an annual basis, associated with each refinery. It should be noted that two refineries, IMC and PCA, exceed the annual standard of 60 microgram per cubic meter (ug/m^3) without consideration being given to natural background. Background was assumed to be 40 ug/m^3 for southeastern New Mexico. This value was selected based on non-urban TSP reported observations near Alamogordo and Las Cruces, Southeastern New Mexico. The data from the stations are shown in Appendix A-3. In a study of rural stations in the United States, reported by Morgan, et al in 1970, the distribution of "backgrounds" was as follows: 10 non-urban stations had TSP of 0 - 19 ug/m^3, 16 stations had 20 - 39 ug/m^3, and 4 had 40 - 59 ug/m^3. When a background of 40 ug/m^3 is utilized, four refineries (Duval, AMAX, IMC and PCA) cause the annual standard to be exceeded.

Table II-48: Maximum Ground Level Concentrations of Suspended Particulates (1975) at the Potash Refineries in Carlsbad Area

Refinery	Max. Annual Ground Level Concentration* (Ug/m^3)	Max. Annual Ground Level Concentration Including Natural Background of 40 (Ug/m^3)	Location in Meters	
			North	East
MCC	12.2	(52.2)	350	50
PCA	74.4	(114.4)	350	50
IMC	65.6	(105.6)	550	50
Duval	31.2	(71.2)	450	50
AMAX	48.9	(88.9)	450	50
NPC	2.6*	(42.6)	350	50
Kerr-McGee	14.8	(54.8)	50	50

* Without natural background; numbers in parentheses are with background.

Figures II-2 through II-8 show the plots of isoconcentration lines of the annual geometric means for the 7 refineries. Due to the low concentrations around NPC and MCC, no isoconcentration lines are shown. The insoconcentration lines and numbers in Figures II-4 through II-8 represent ug/m^3, Figure II-9 shows the composite annual geometric mean centrations for all 7 refineries. The highest concentrations occur along the western group of 5 refineries.

The CDM was also utilized to determine the monthly (30-day) averages for the four refineries exceeding the annual suspended particulate standard. Calculations were made for all 12 months for the PCA and IMC refineries since they exhibited the highest annual geometric means. The calculated concentrations for each month for the PCA refinery are shown in Figures II-10 through II-21 and for the IMC refinery in Figures II-22 through II-33. Examination of these figures reveals that June is the worst month in terms of ground level concentrations, and this is followed closely by July. The ground level concentrations during June were also calculated for the AMAX and Duval refineries, and the results are shown in Figures II-34 and II-35 respectively. A summary of the June peak concentrations of the 4 refineries is shown in Table II-49. Since the standard for the 30-day average is 90 ug/m^3, three refineries (PCA, IMC, and AMAX) exceed the standard when background is considered.

The maximum 24-hour concentration and its distance from each refinery was then determined, based on the procedure as described in Appendix A-2. These calculations were made for the D and F stability classifications. Classification D (neutral stability) was chosen since it represents the most frequently occurring condition (occurs 51.1% of the time); and Classification F (stable to extremely stable) was chosen since it represents the worst dispersion condition. Classification F occurs 12.8 percent of the time. The results of this analysis are shown in Table II-50. Stability classification F generally yields the highest ground level concentrations, and all refineries except National exceed the 24-hour standard of 150 ug/m^3. The Kerr-McGee refinery only silightly exceeds the standard (157 ug/m^3 to 150 ug/m^3).

Finally, it is noted that no calculations are provided for the ground level concentrations of NO_x, SO_x, HC and CO. These pollutants are emitted in low quantities relative to the regional emission inventories as shown in Table II-17. In addition, air quality measurements for NO_x and SO_x in

Region 5 indicate that the air quality for these two pollutants is considerably less than applicable standards. No air quality measurements are available in Region 5 for HC and CO.

Scale on computer Air Emission is as follows:

Individual Plant Maps

Horizontal Extent of Map Equals 1900 Meters

Vertical Extent of Map Equals 2900 Meters

Regional Maps

Horizontal Extent of Map Equals 23,750 Meters

Vertical Extent of Map Equals 36,250 Meters

The maximum annual ground level concentrations (background not included) in relation to the particulate emissions in pounds per ton are as follows:

MCC	12.2 ug/m^3	7.73 lb/ton
PCA	74.4 ug/m^3	9.49 lb/ton
IMC	65.6 ug/m^3	23.90 lb/ton
Duval	31.2 ug/m^3	7.88 lb/ton
AMAX	48.9 ug/m^3	7.51 lb/ton
NPC	2.6 ug/m^3	0.52 lb/ton
Kerr-McGee	14.8 ug/m^3	1.71 lb/ton

In general, the maximum ground level concentrations increase in relation to increasing emissions in lb/ton; however, the relationship does not account for total production tonnage or differences in the heights of stacks and effluent gas temperatures.

Predicted Annual Concentrations of Suspended Particulates Around MCC Refinery (Isoconcentration lines based on annual geometric means ug/m^3) Intersection of Horizontal and Vertical Lines Represents the Point of Refinery Emissions

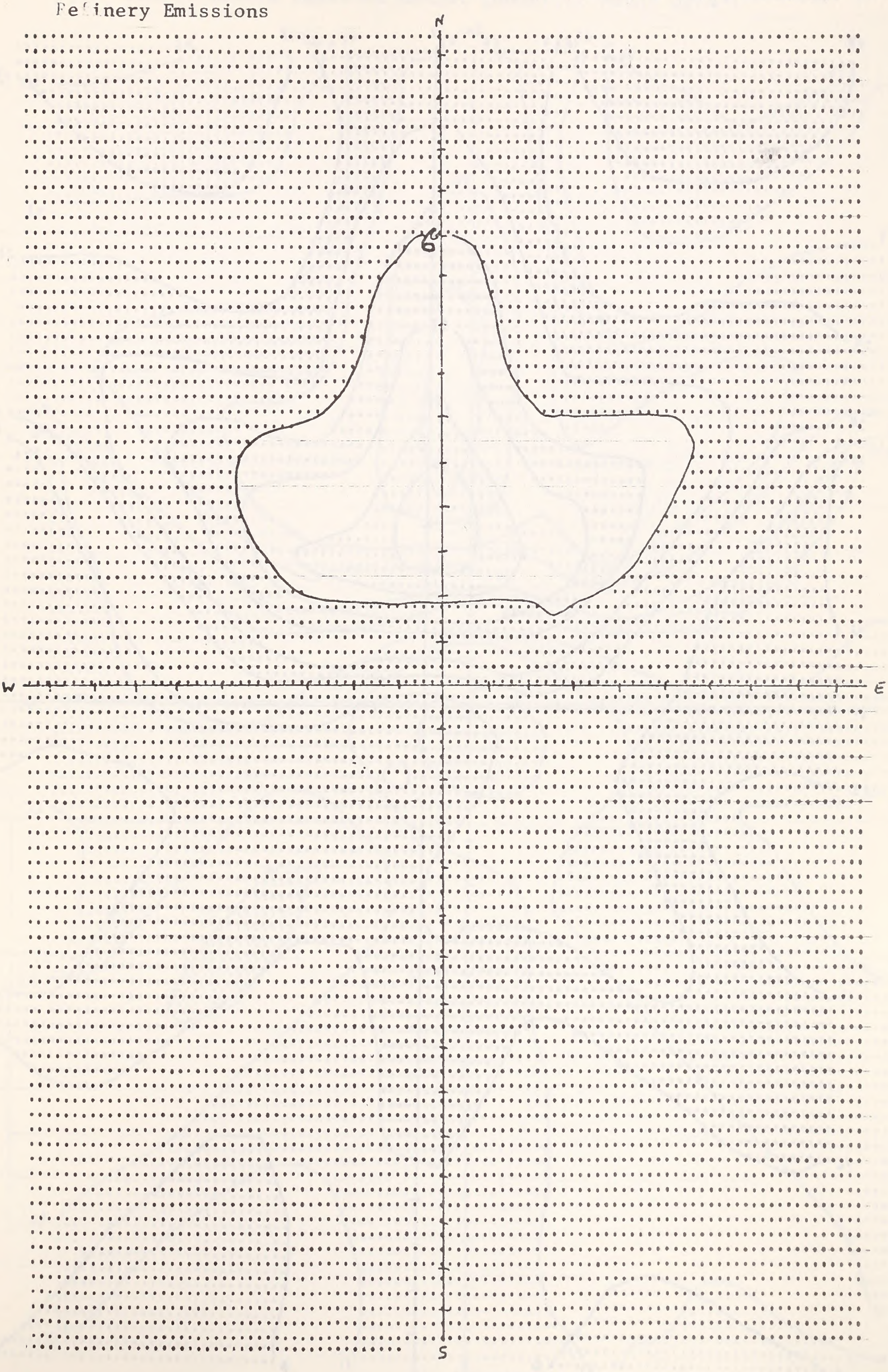
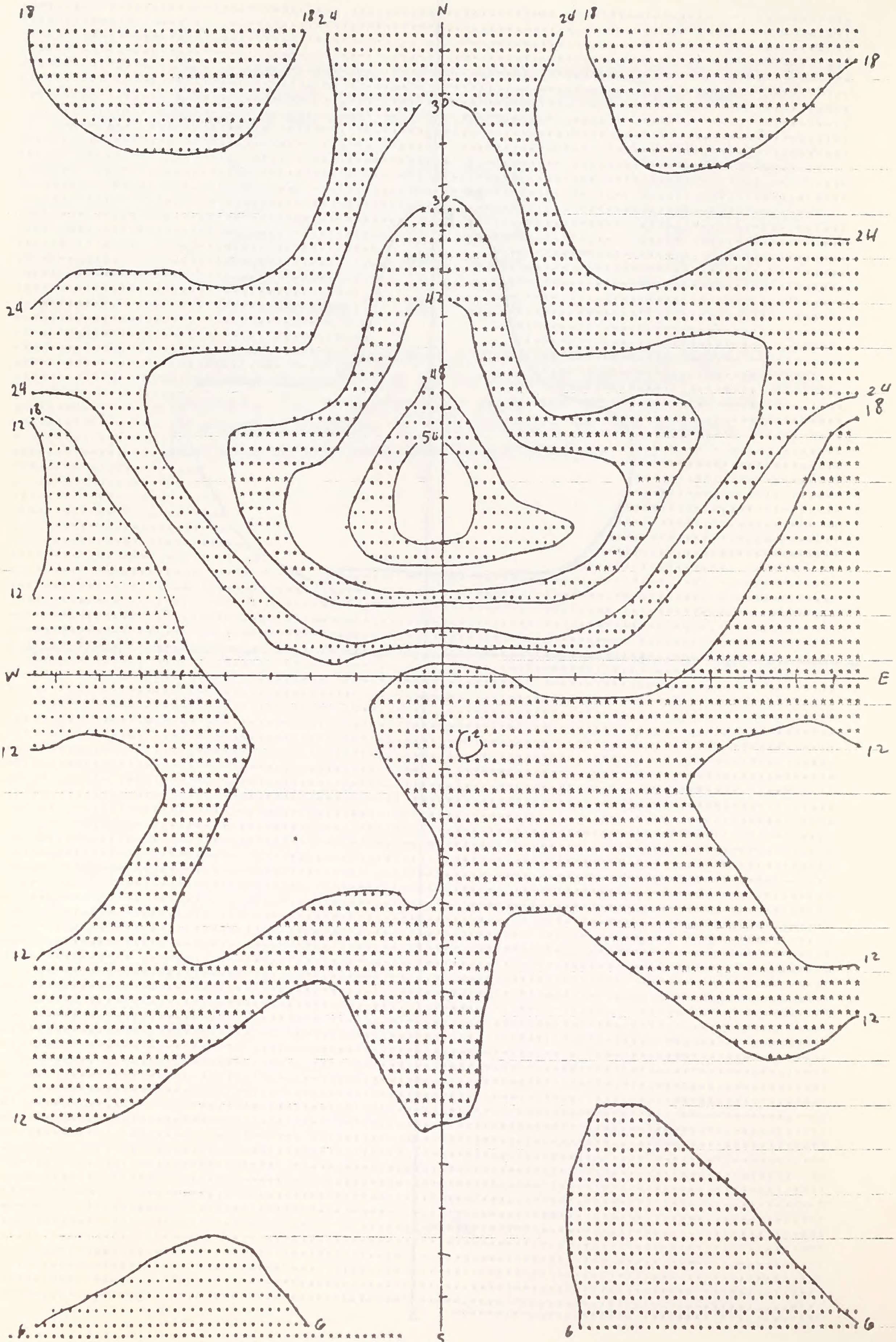


FIGURE II-2

Predicted Annual Concentrations of Suspended Particulates Around
Potash Company of America Refinery
(isoconcentrations based on annual geometric means ug/m^3

FIGURE II-3



Predicted Annual Concentrations of Suspended Particulates Around International Minerals Corporation Refinery
(isoconcentrations based on annual geometric means ug/m3)

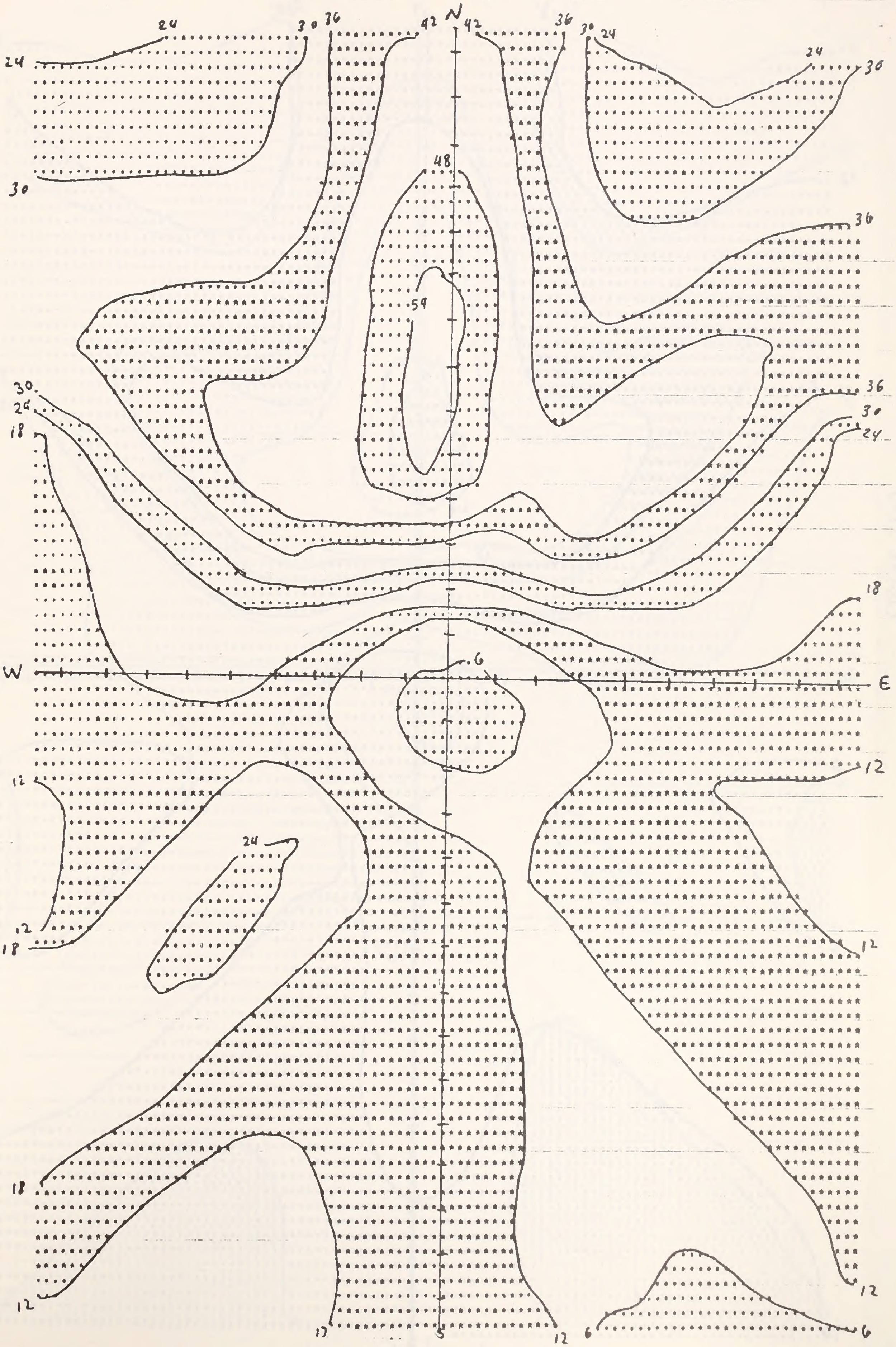


FIGURE II-4

Predicted Annual Concentrations of Suspended Particulates Around Duval Chemical Corporation Refinery
(isoconcentrations based on annual geometric means ug/m^3)

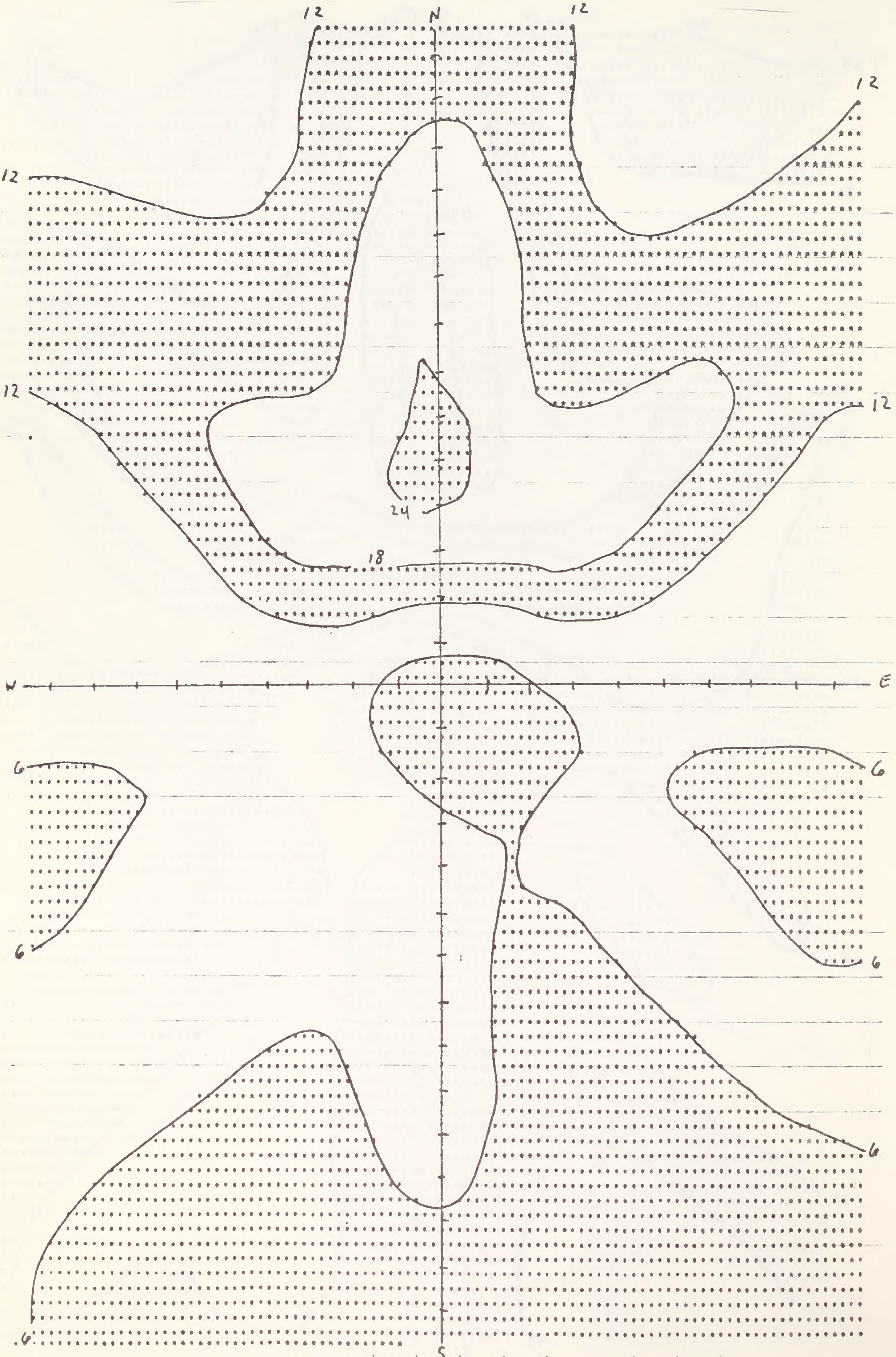


FIGURE II-5

Predicted Annual Concentrations of Suspended Particulates Around AMAX Chemical Corporation Refinery
(isoconcentrations based on annual geometric means ug/m^3)

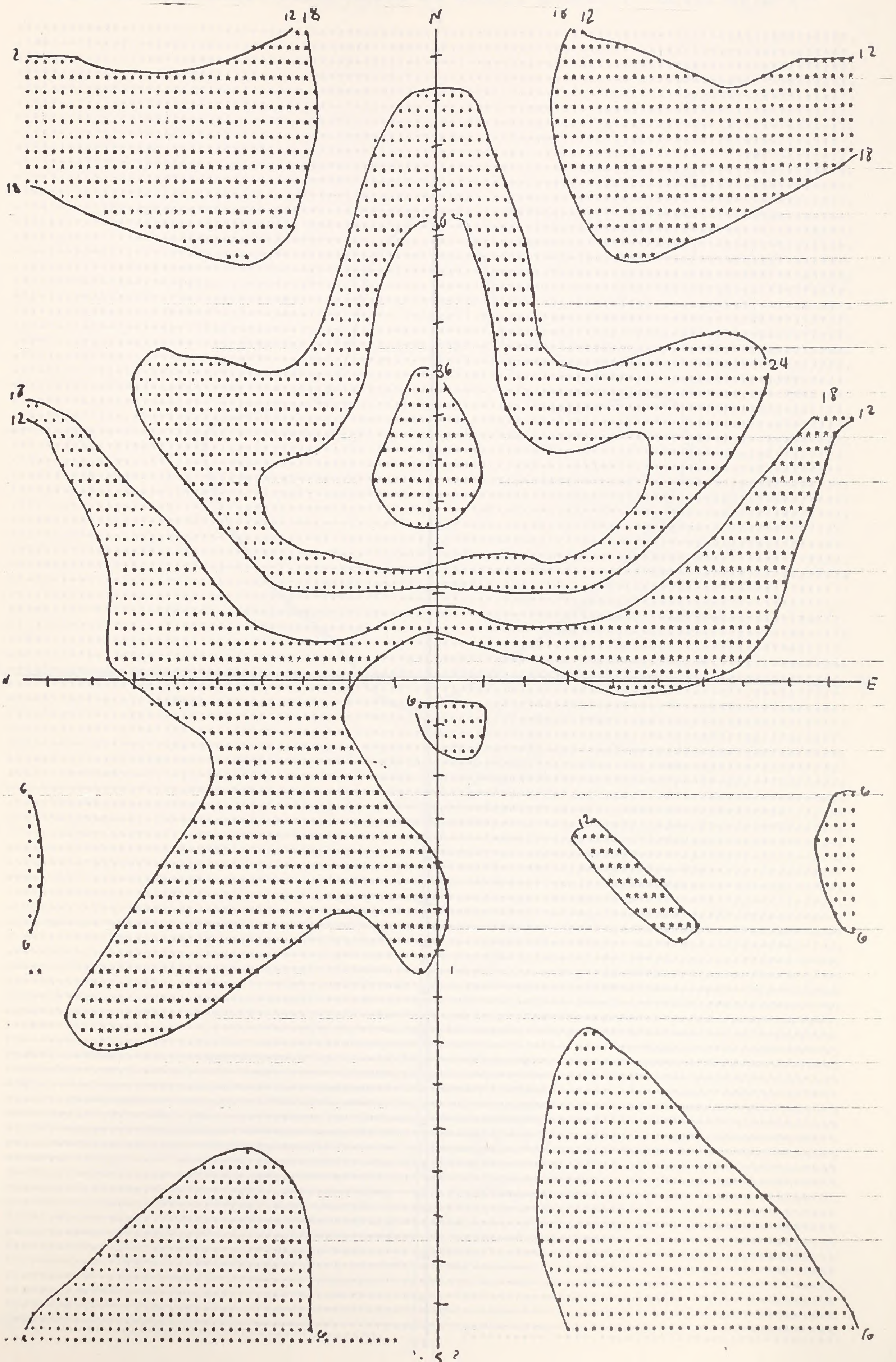
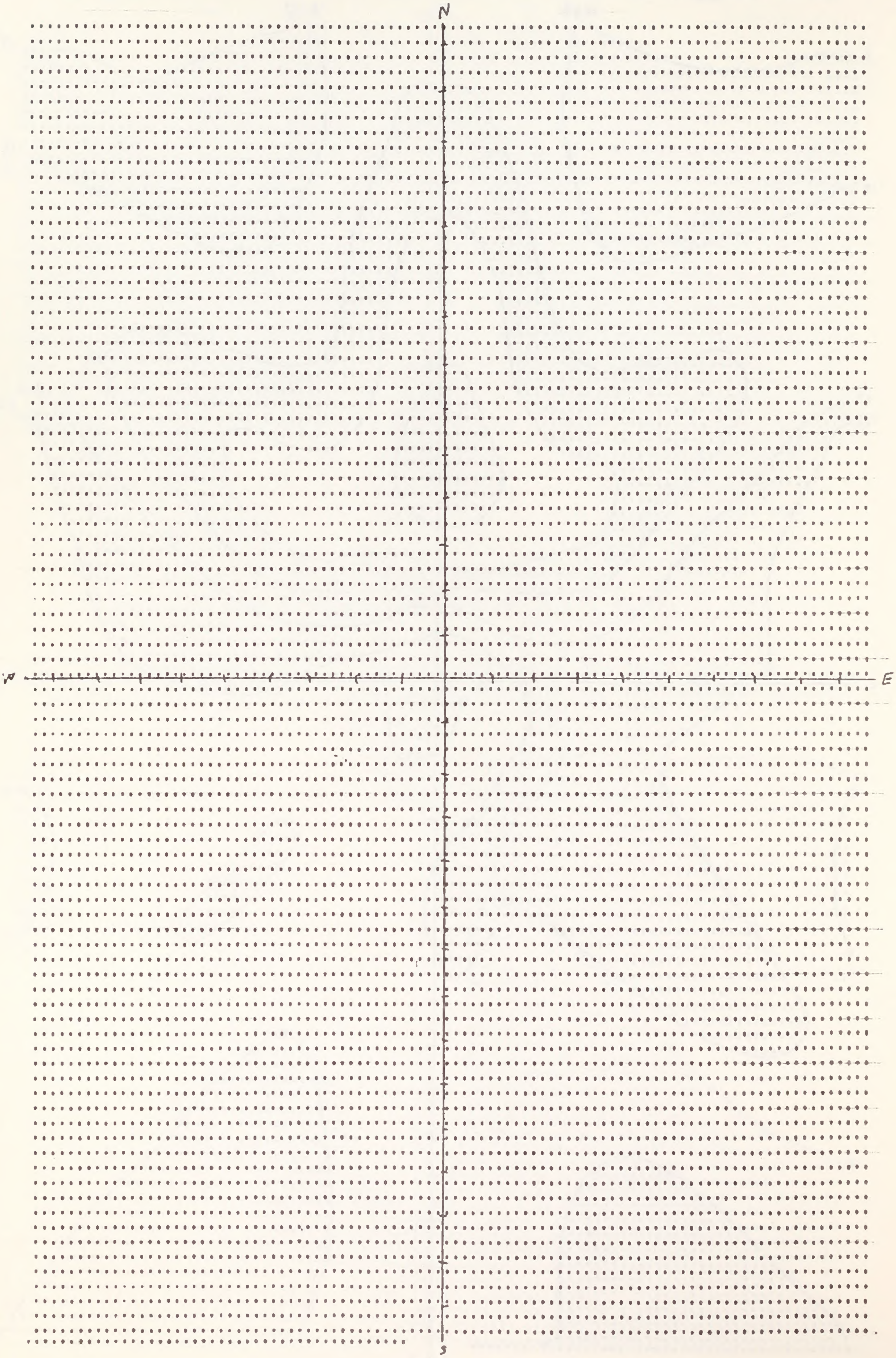


FIGURE II-6

FIGURE II-7

Predicted Annual Concentrations of Suspended Particulates Around National Potash Corporation Refinery
(isoconcentration lines based on annual geometric means ug/m^3)



Predicted Annual Concentrations of Suspended Particulates Around Kerr-McGee Chemical Corporation Refinery
(isoconcentration lines based on annual geometric means mg/m^3)

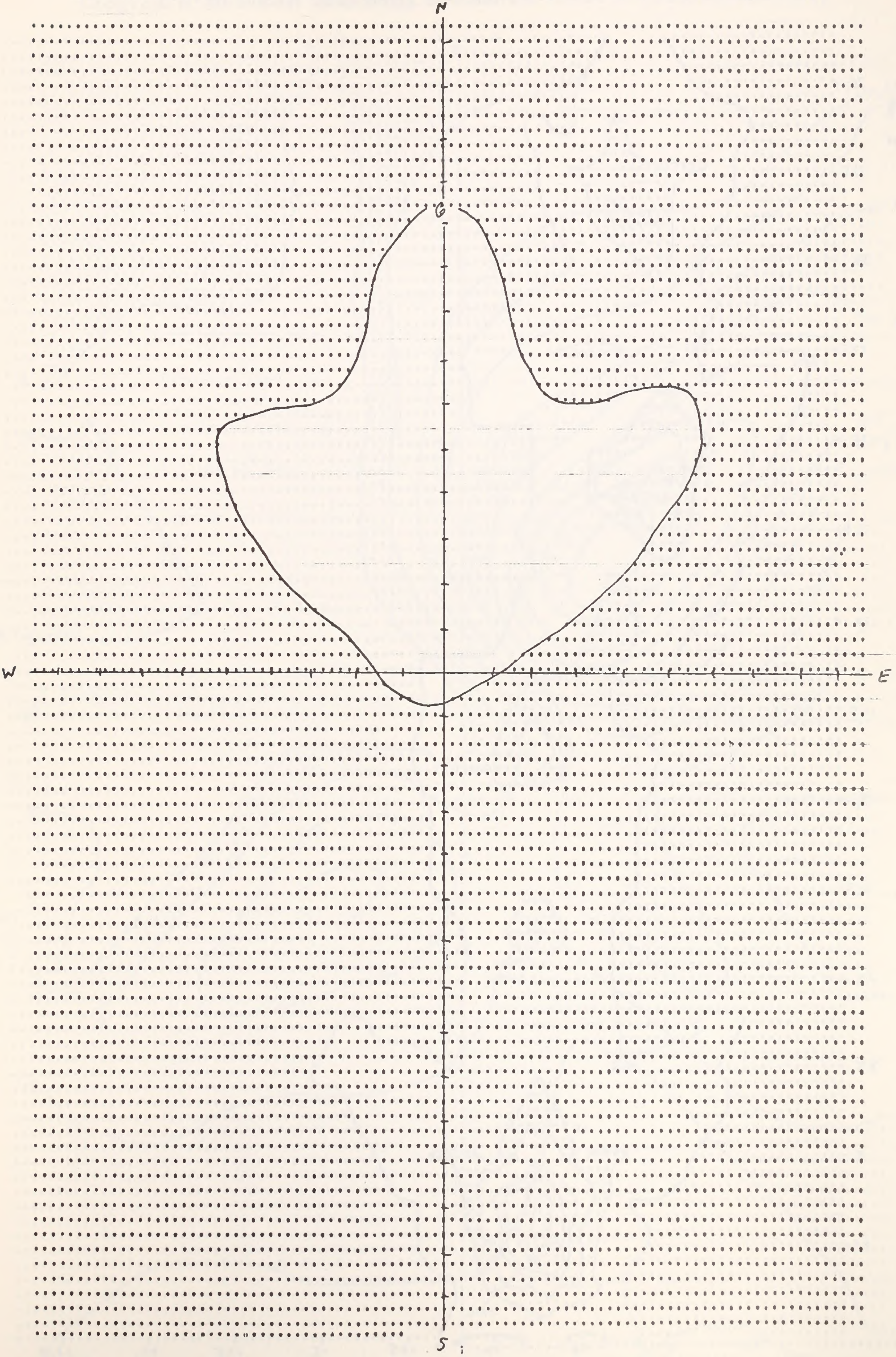
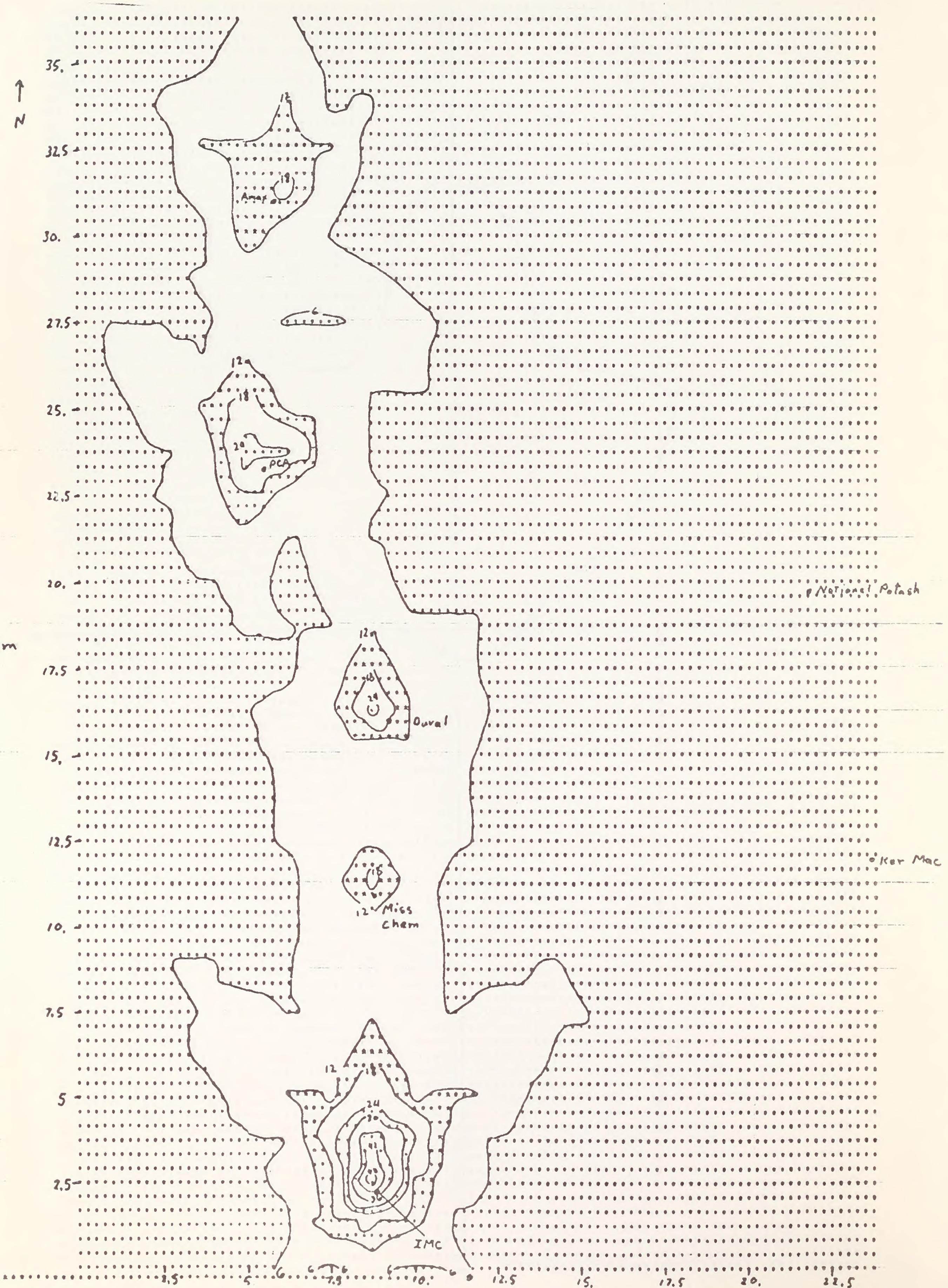


FIGURE II-8

Predicted Annual Concentrations of Suspended Particulates in
Vicinity of Potash Refineries
(isoconcentrations based on annual geometric means ug/m^3)

FIGURE II-9



Predicted January Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average (ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions.

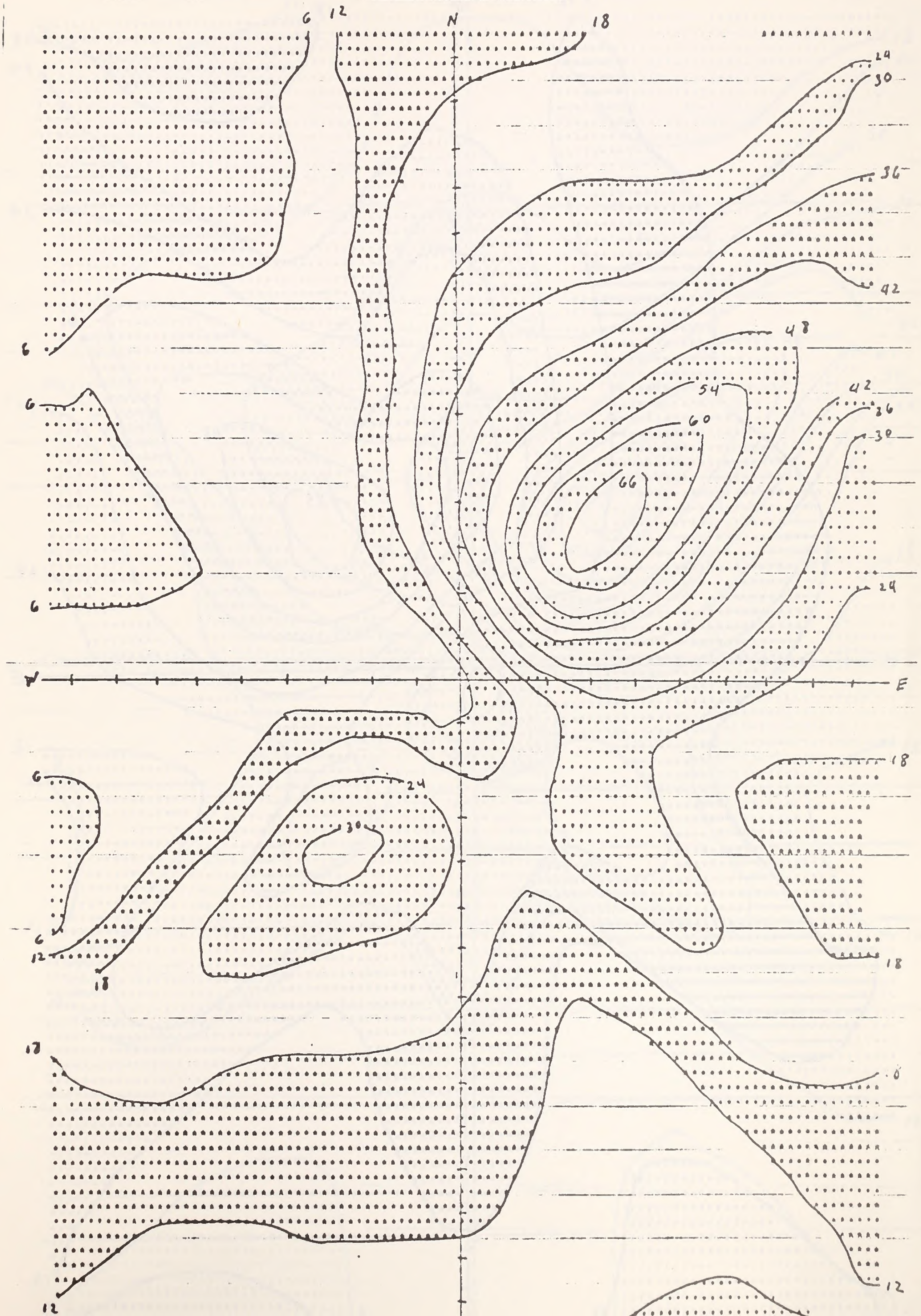


FIGURE II-10

Predicted February Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

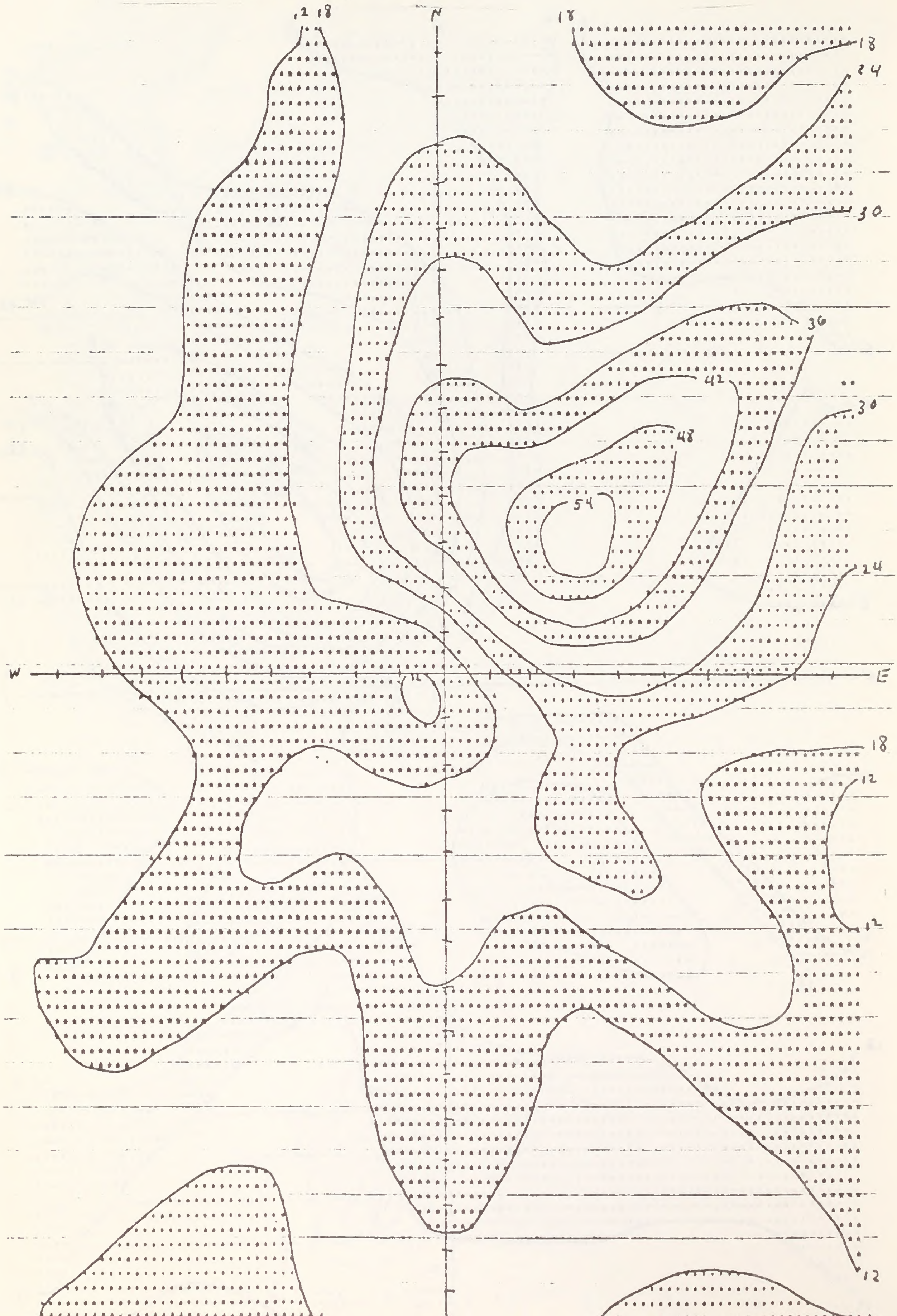


FIGURE II-11

Predicted March Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

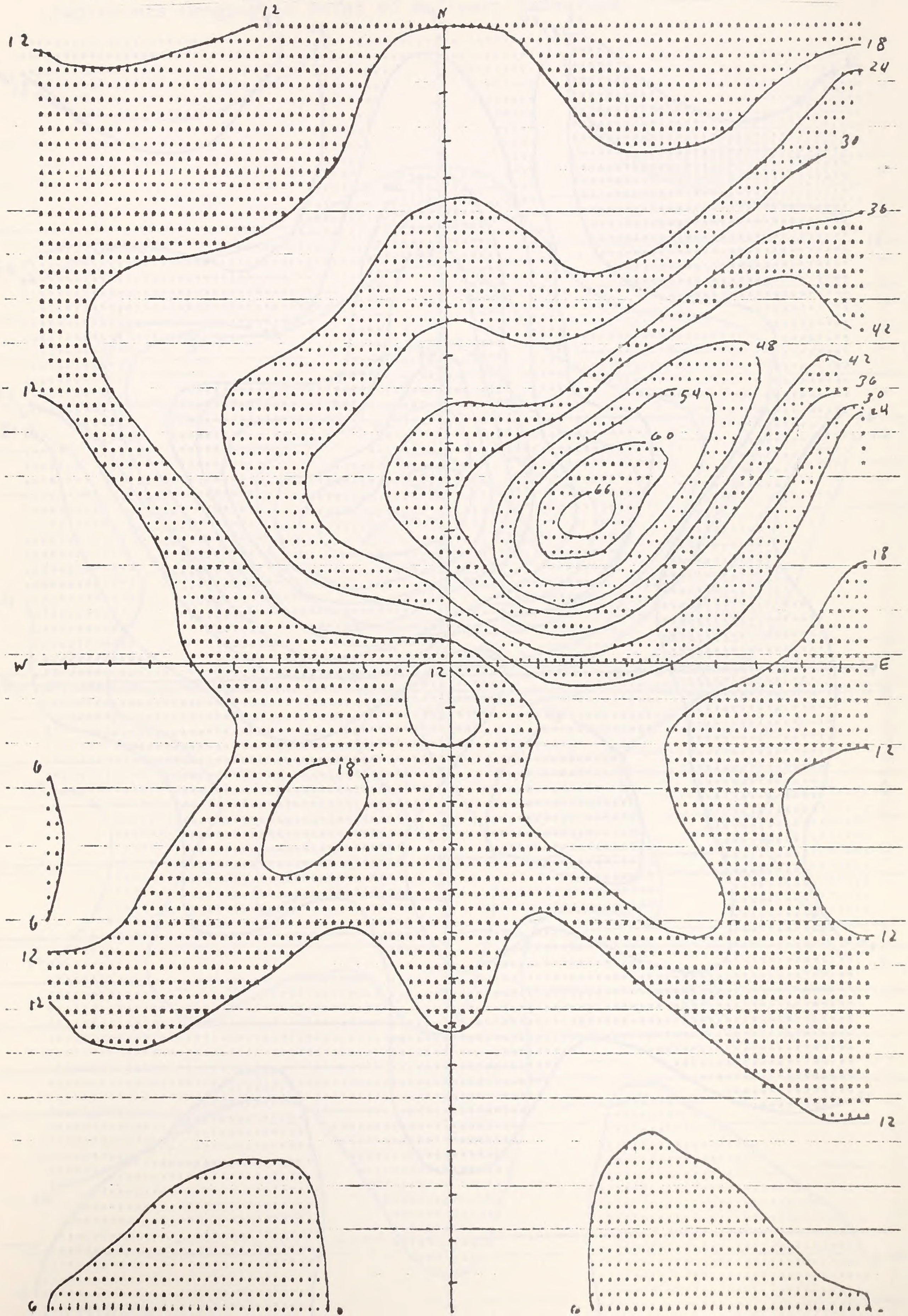


FIGURE II-12

Predicted April Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

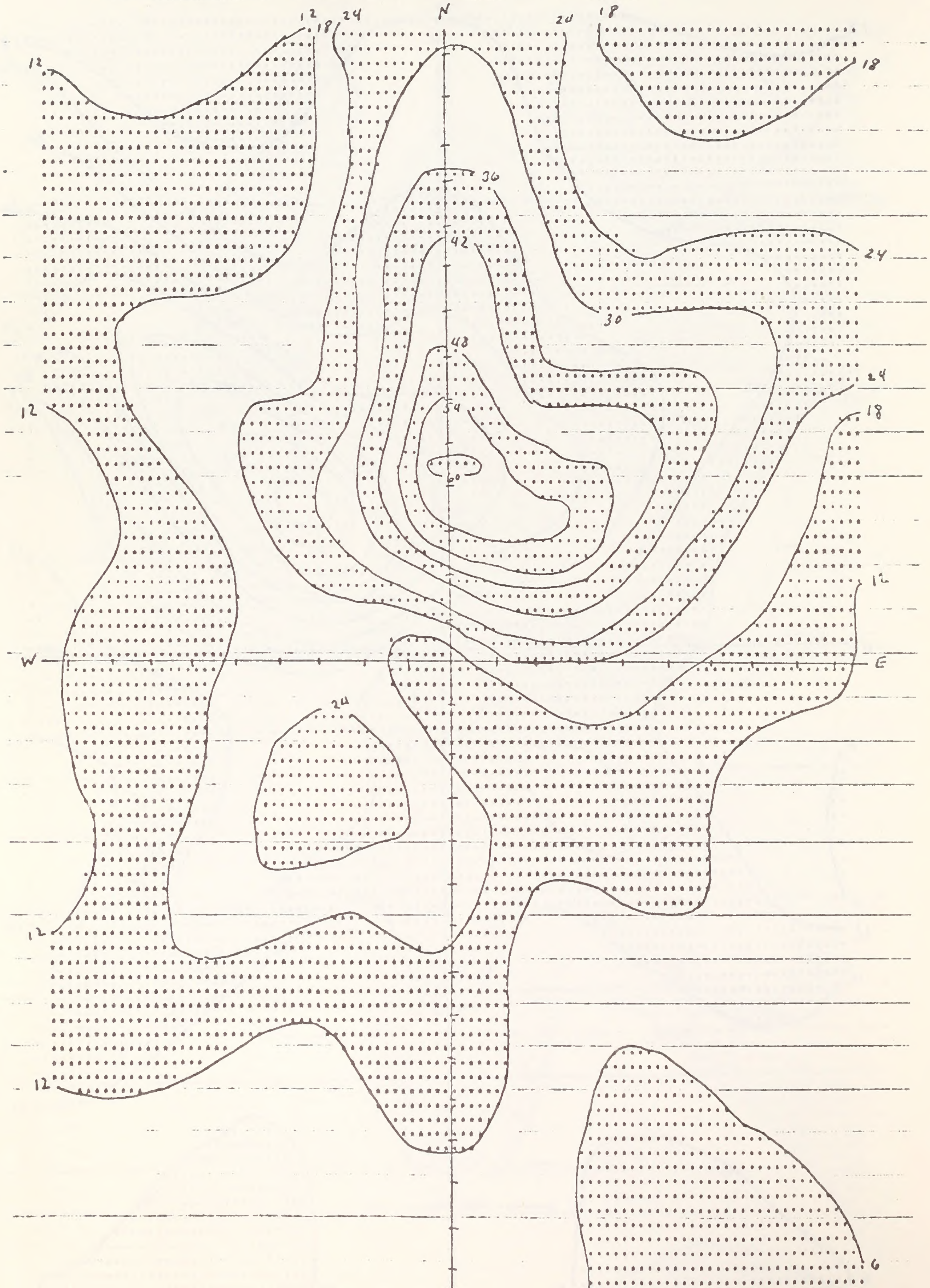


FIGURE II-13

Predicted May Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

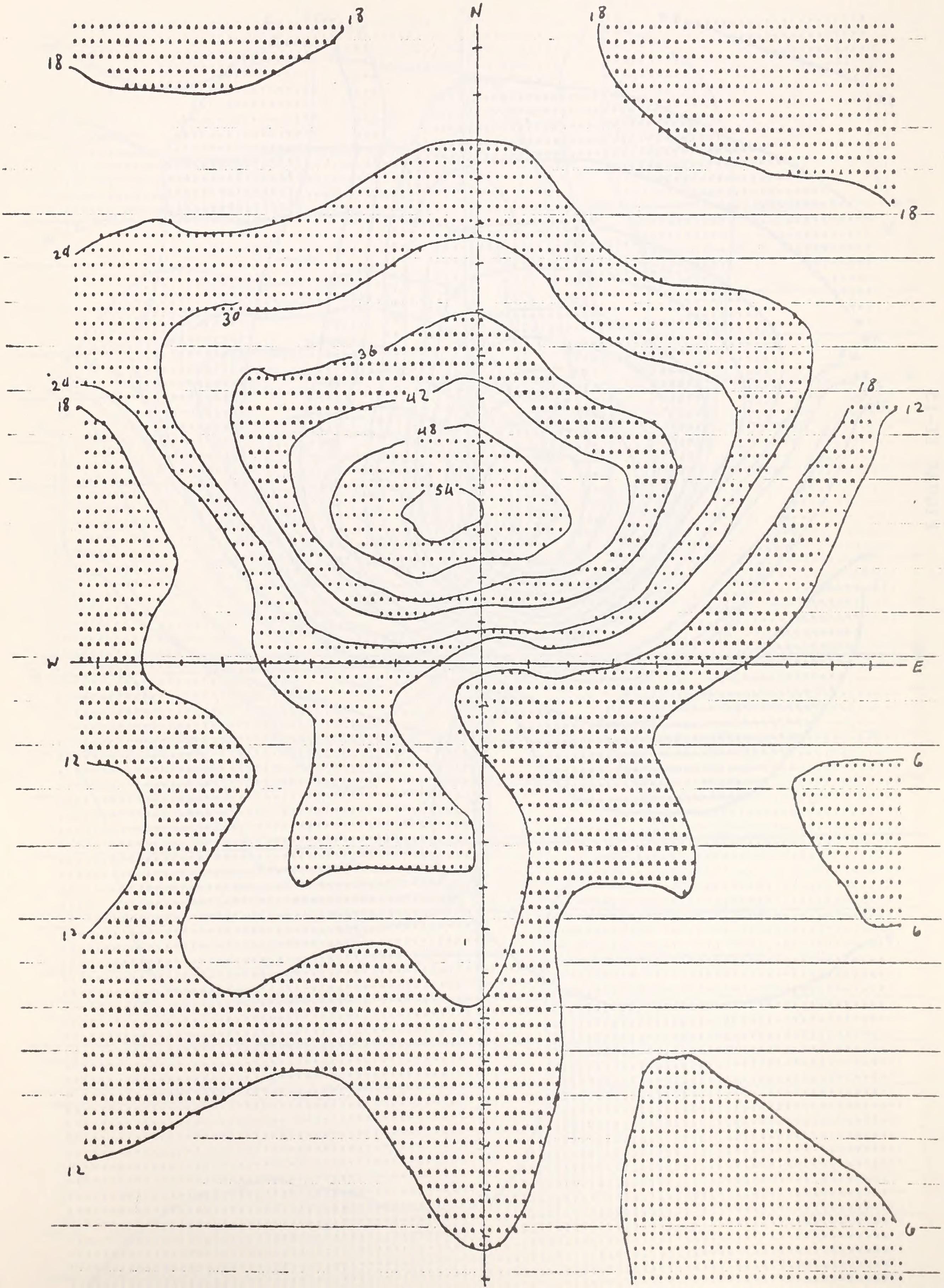
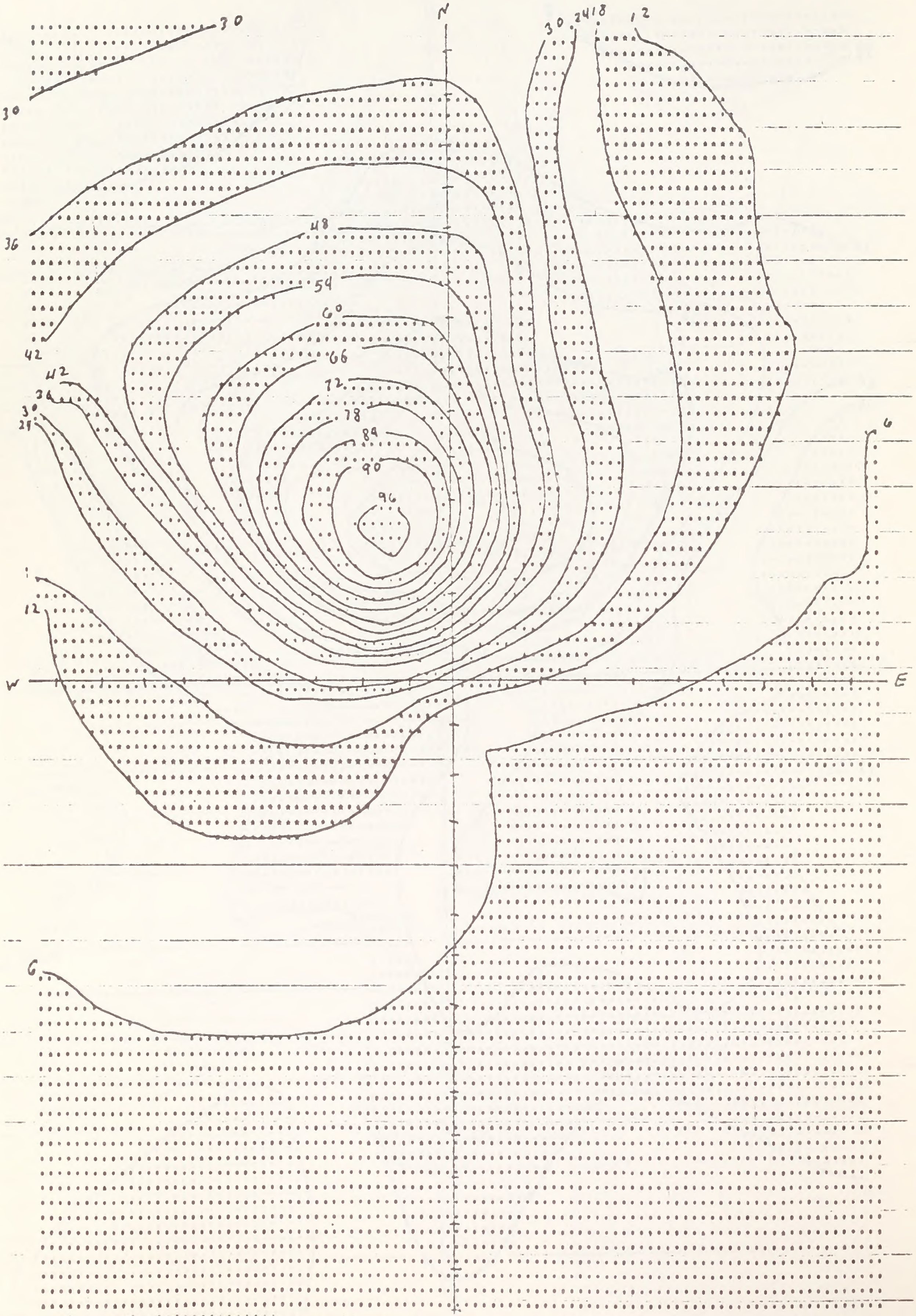


FIGURE II-14

Predicted June Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

FIGURE II-15



Predicted July Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

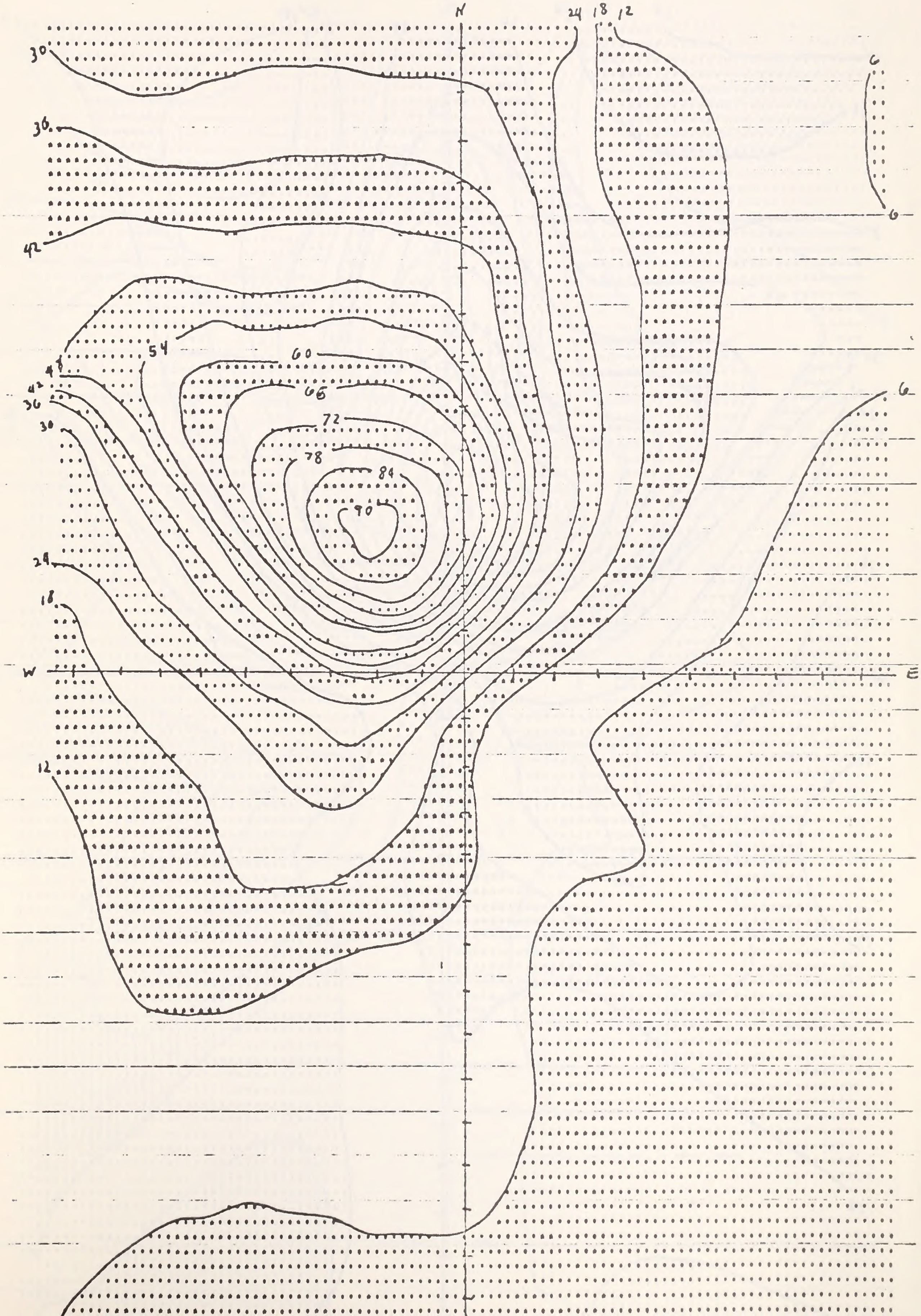


FIGURE II-16

Predicted August Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

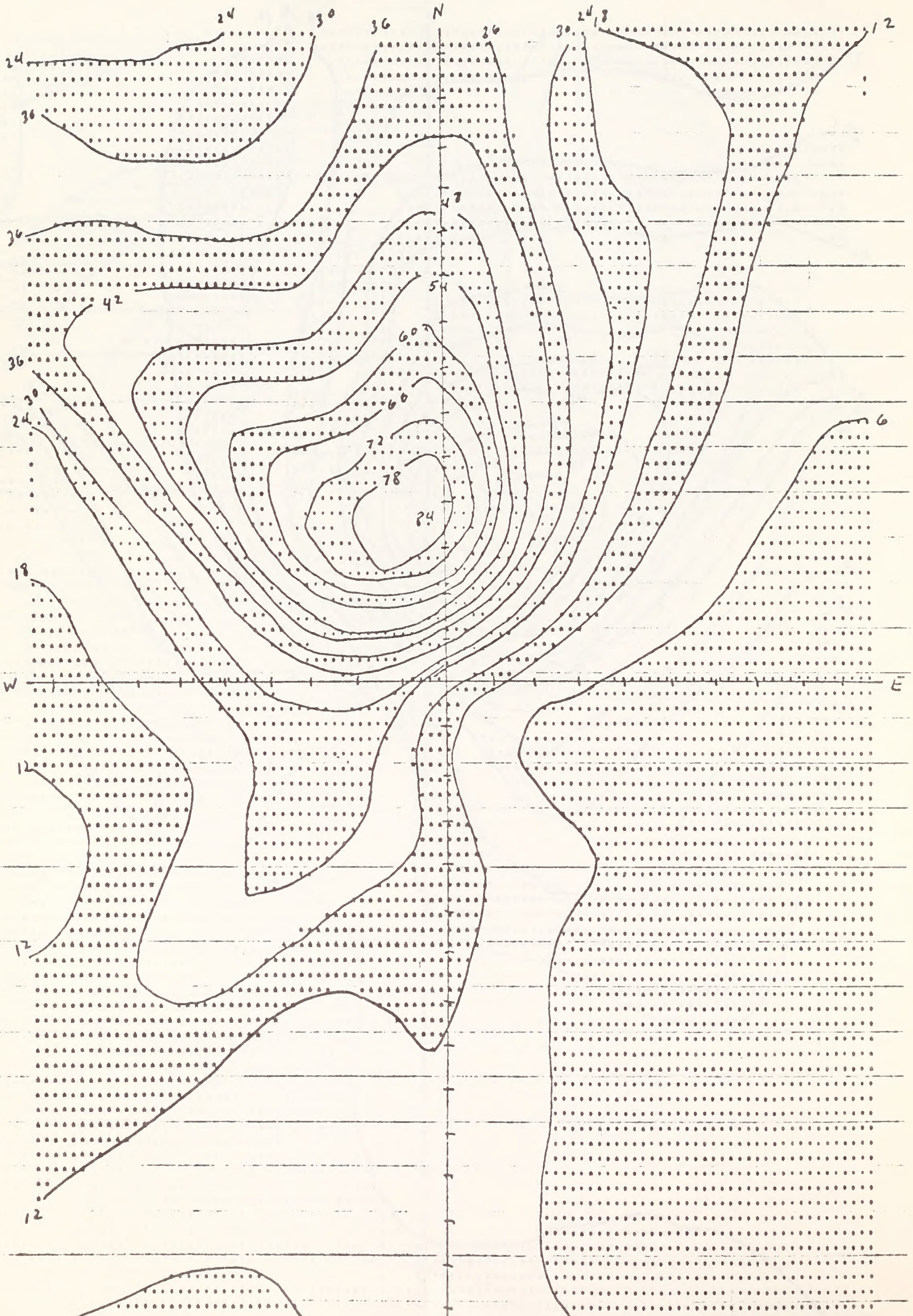


FIGURE II-17

Predicted September Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

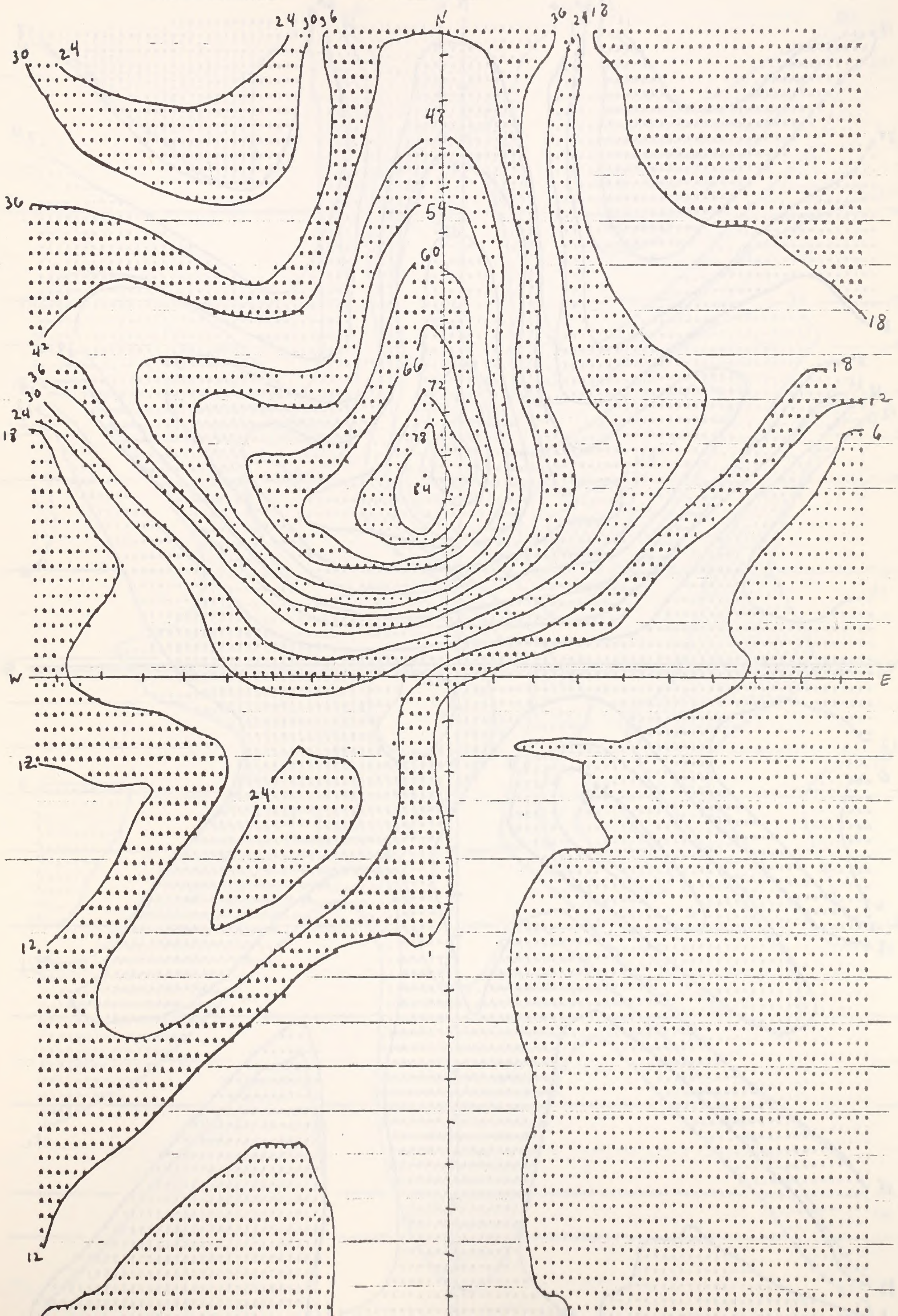


FIGURE II-18

Predicted October Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

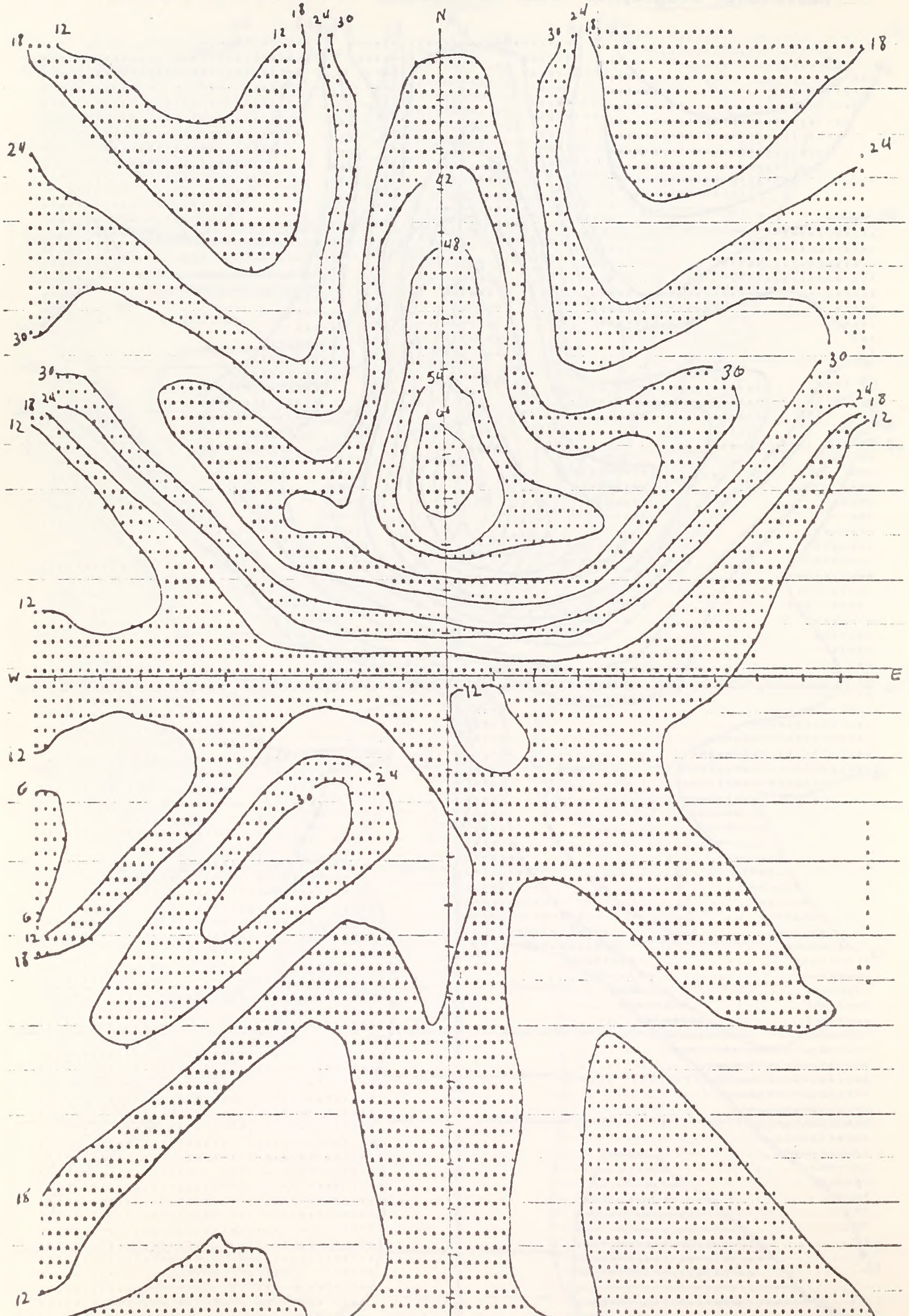


FIGURE II-19

Predicted November Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

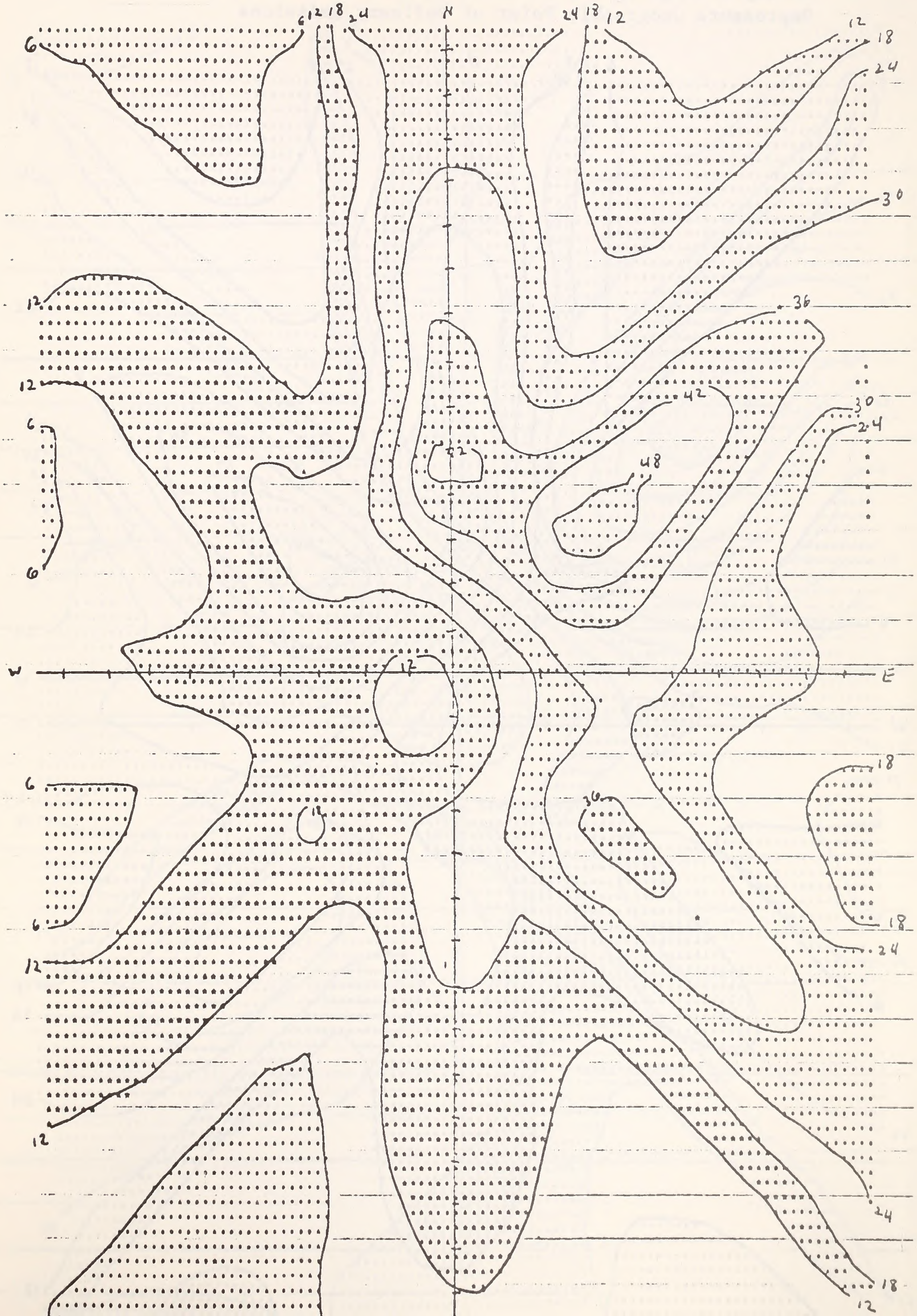
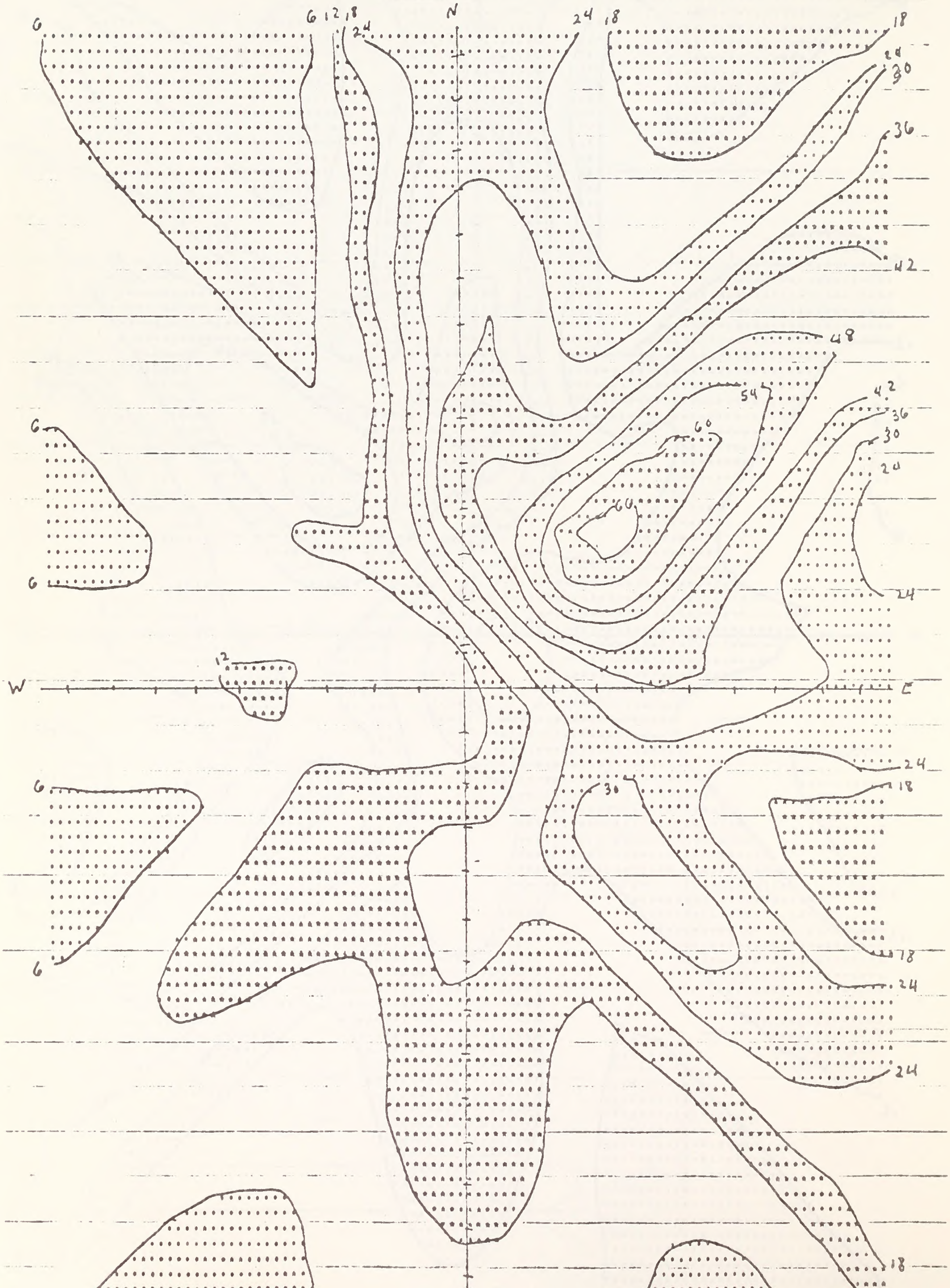


FIGURE II-20

FIGURE II-21

Predicted December Concentrations of Suspended Particulates in Environs of Potash Company of America Refinery (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions



Predicted January Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

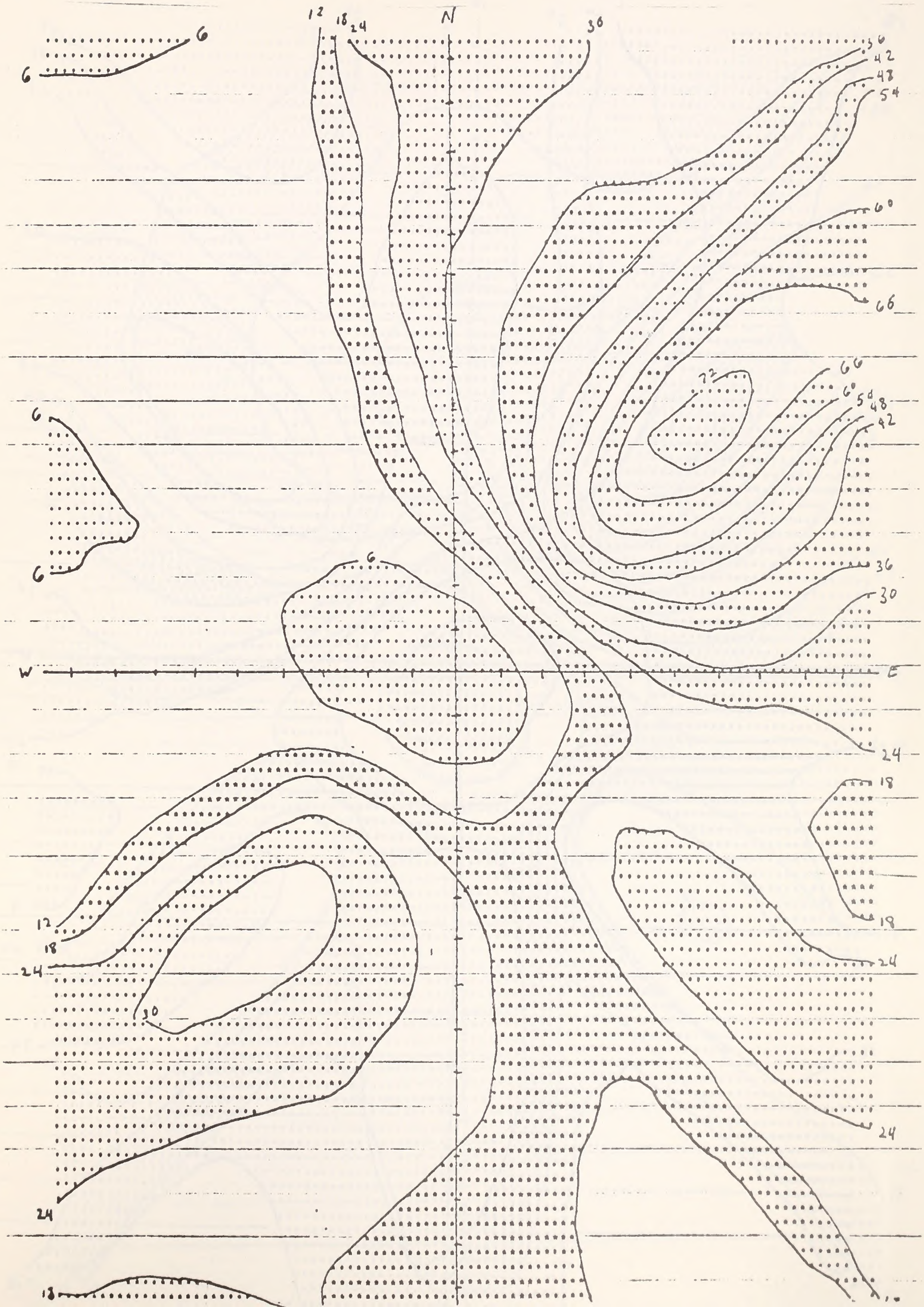
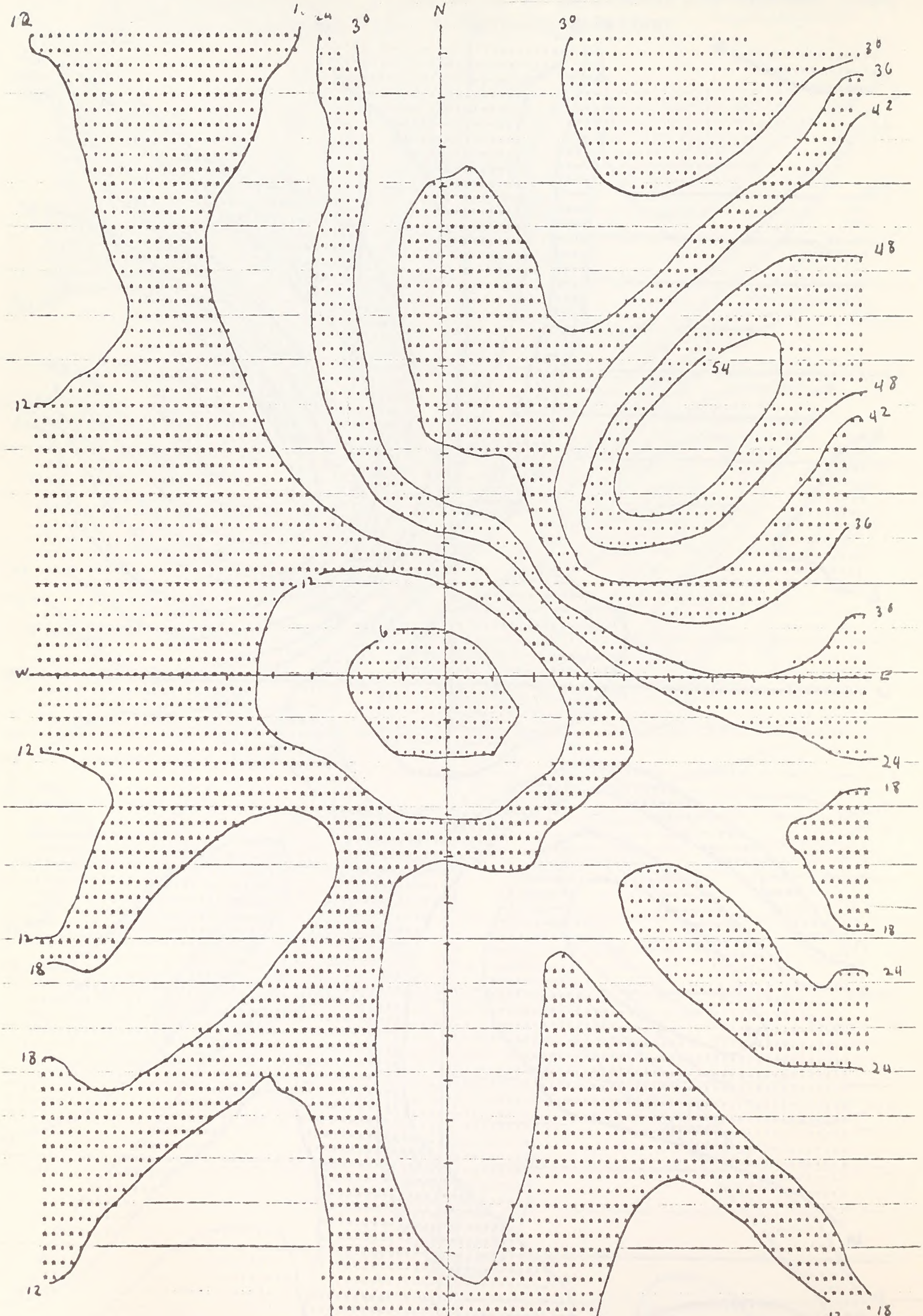


FIGURE II-22

FIGURE II-23

Predicted February Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions.



Predicted March Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

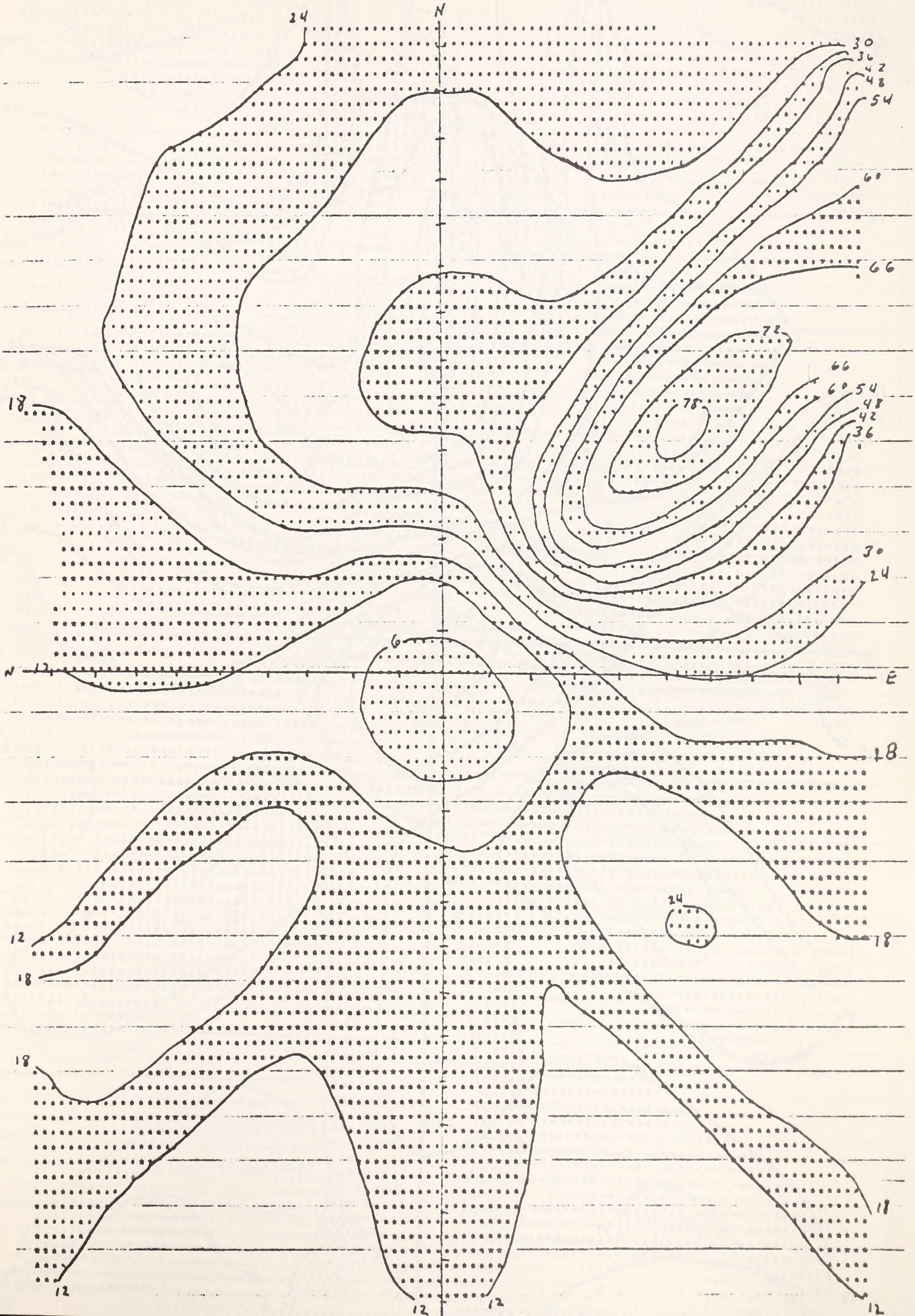


FIGURE II-24

Predicted April Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-Day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

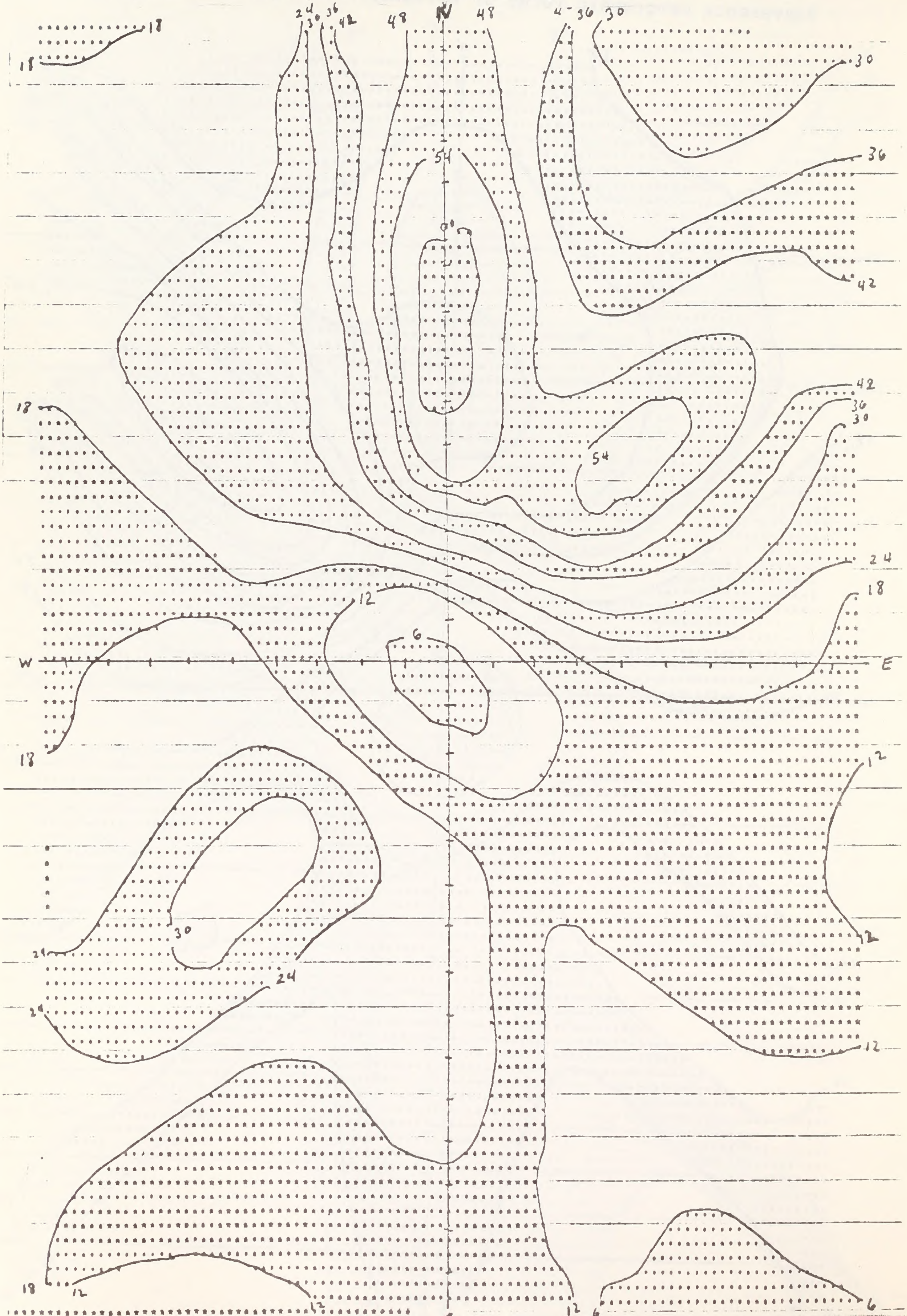


FIGURE II-25

Predicted May Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

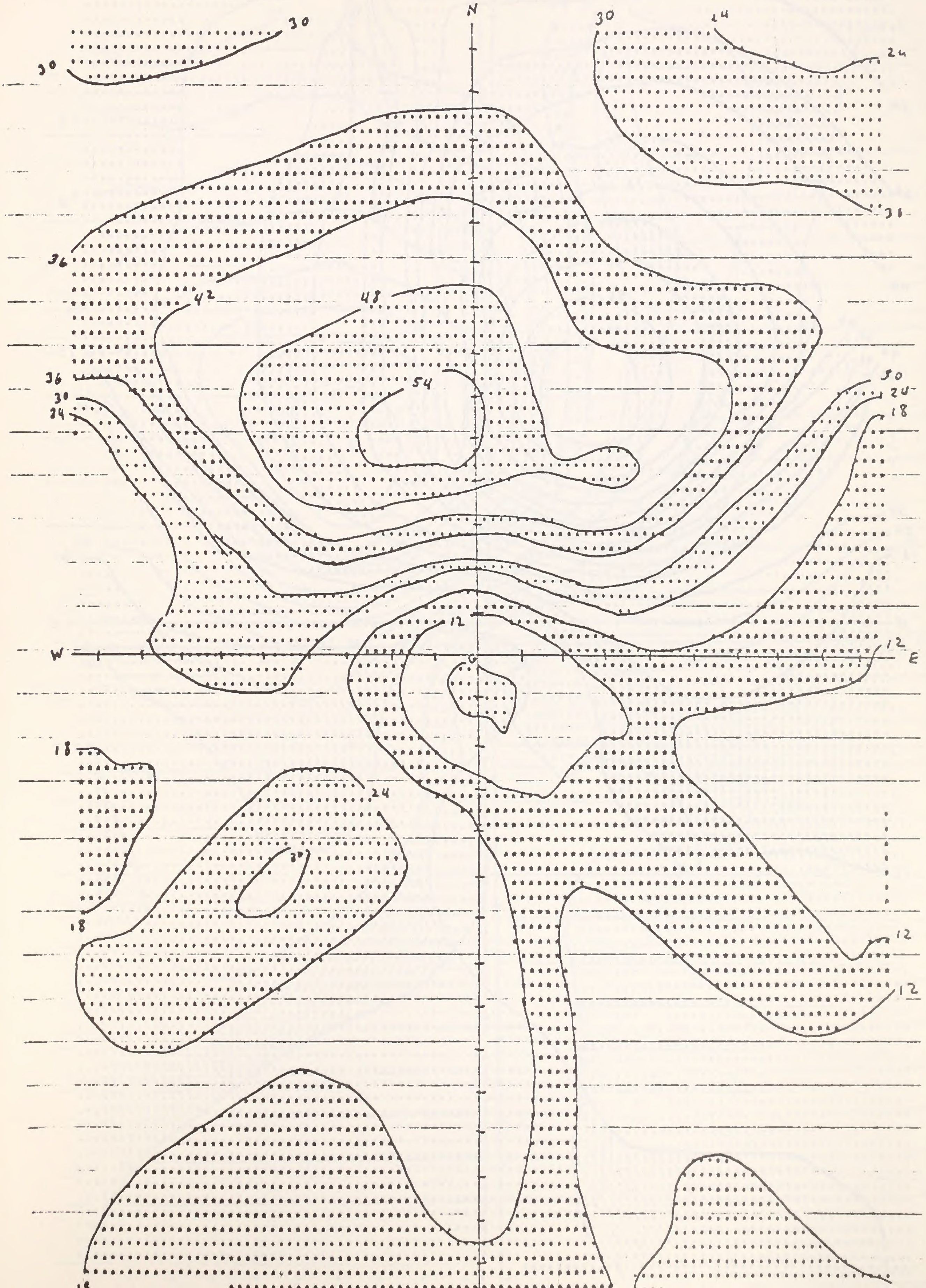


FIGURE II-26

Predicted June Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

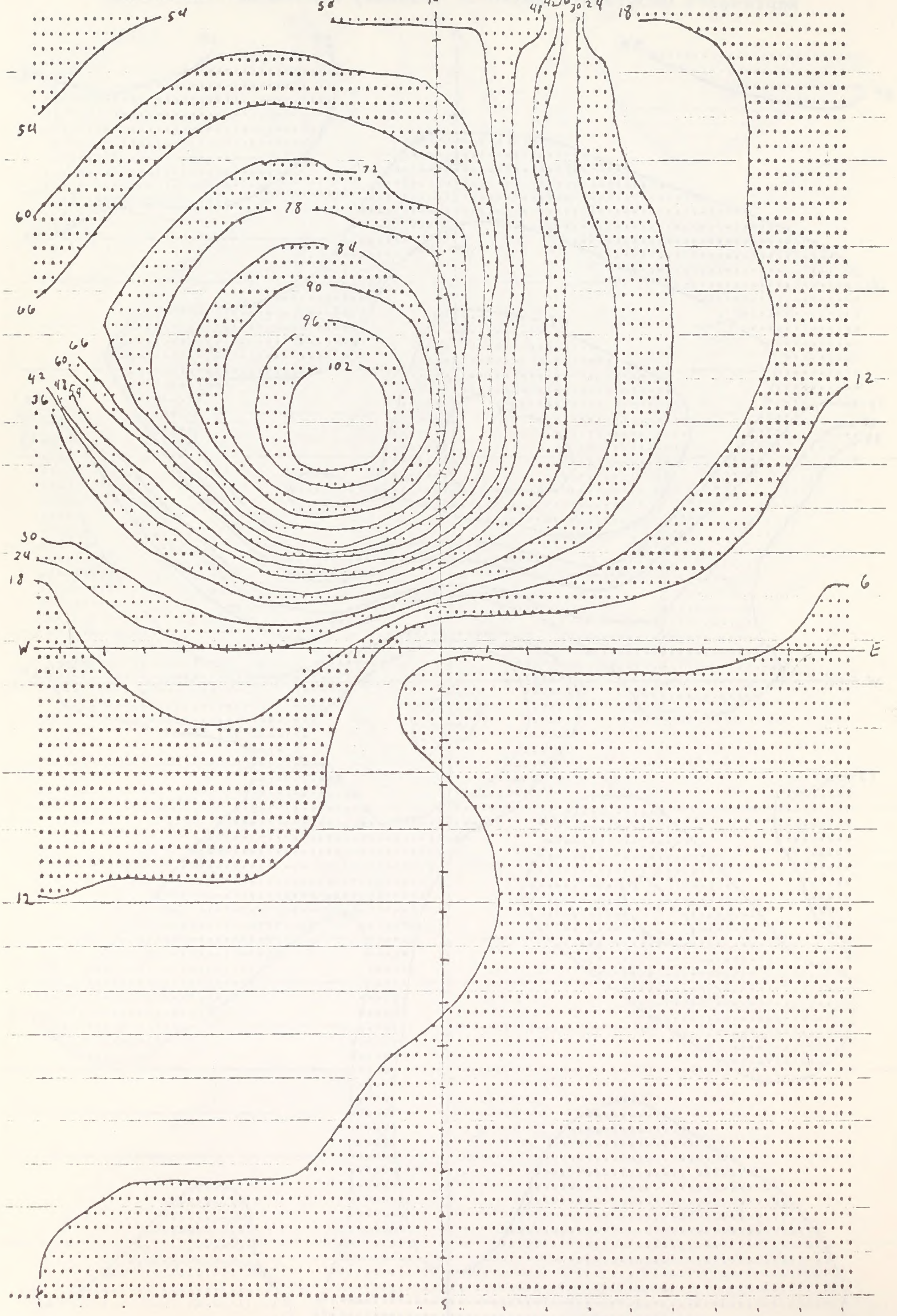


FIGURE II-27

Predicted July Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

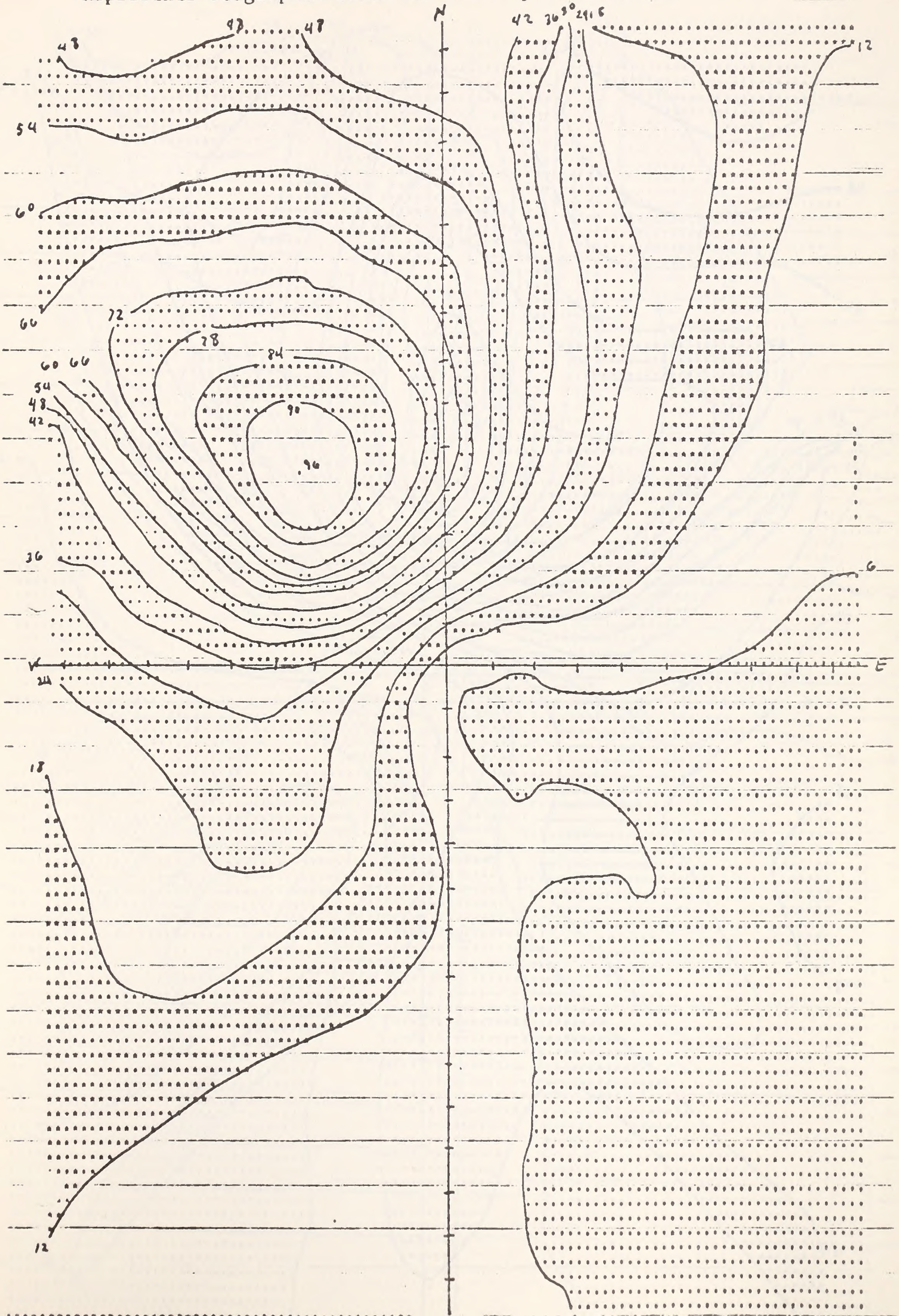


FIGURE II-28

Predicted August Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

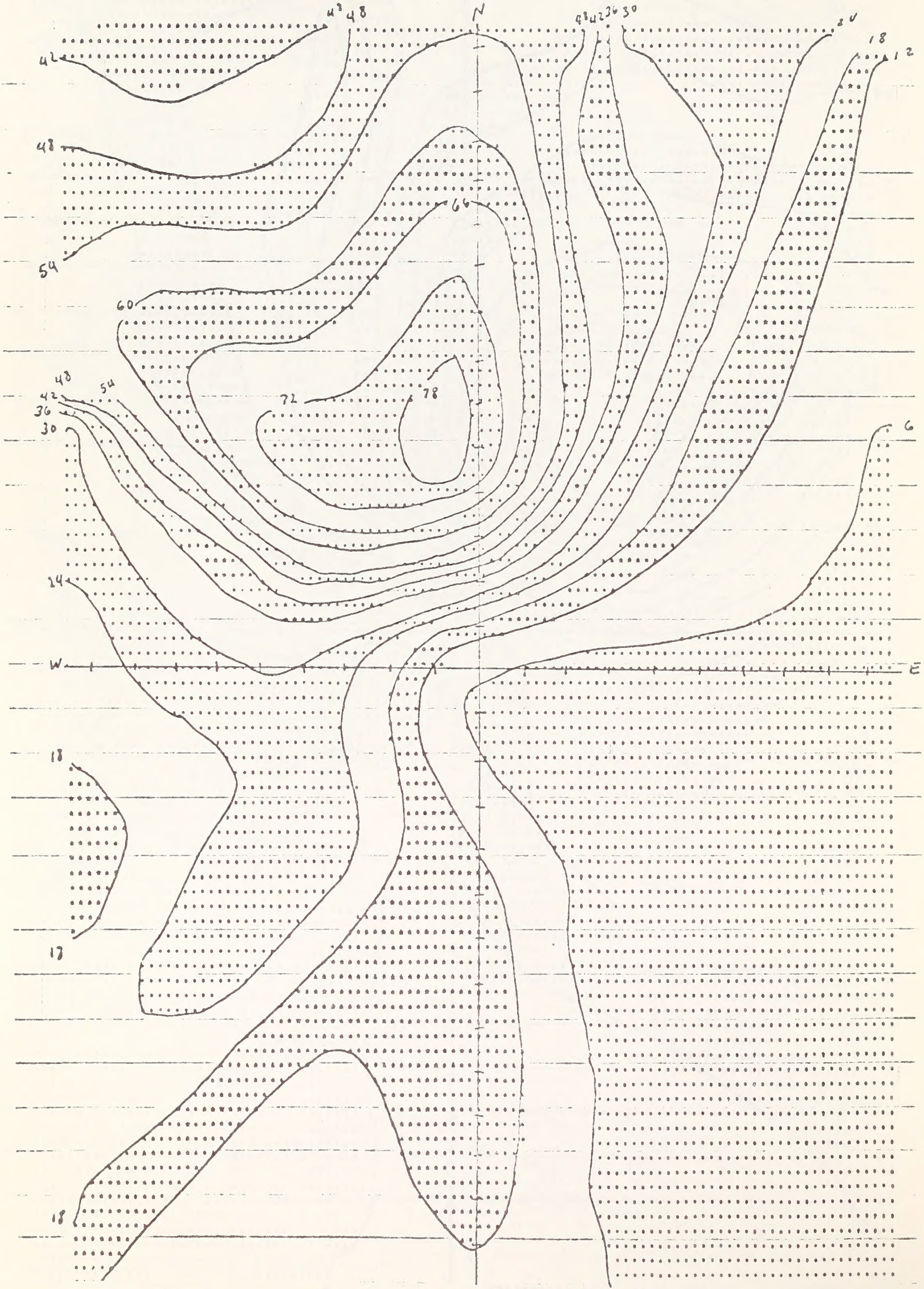


FIGURE II-29

Predicted September Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

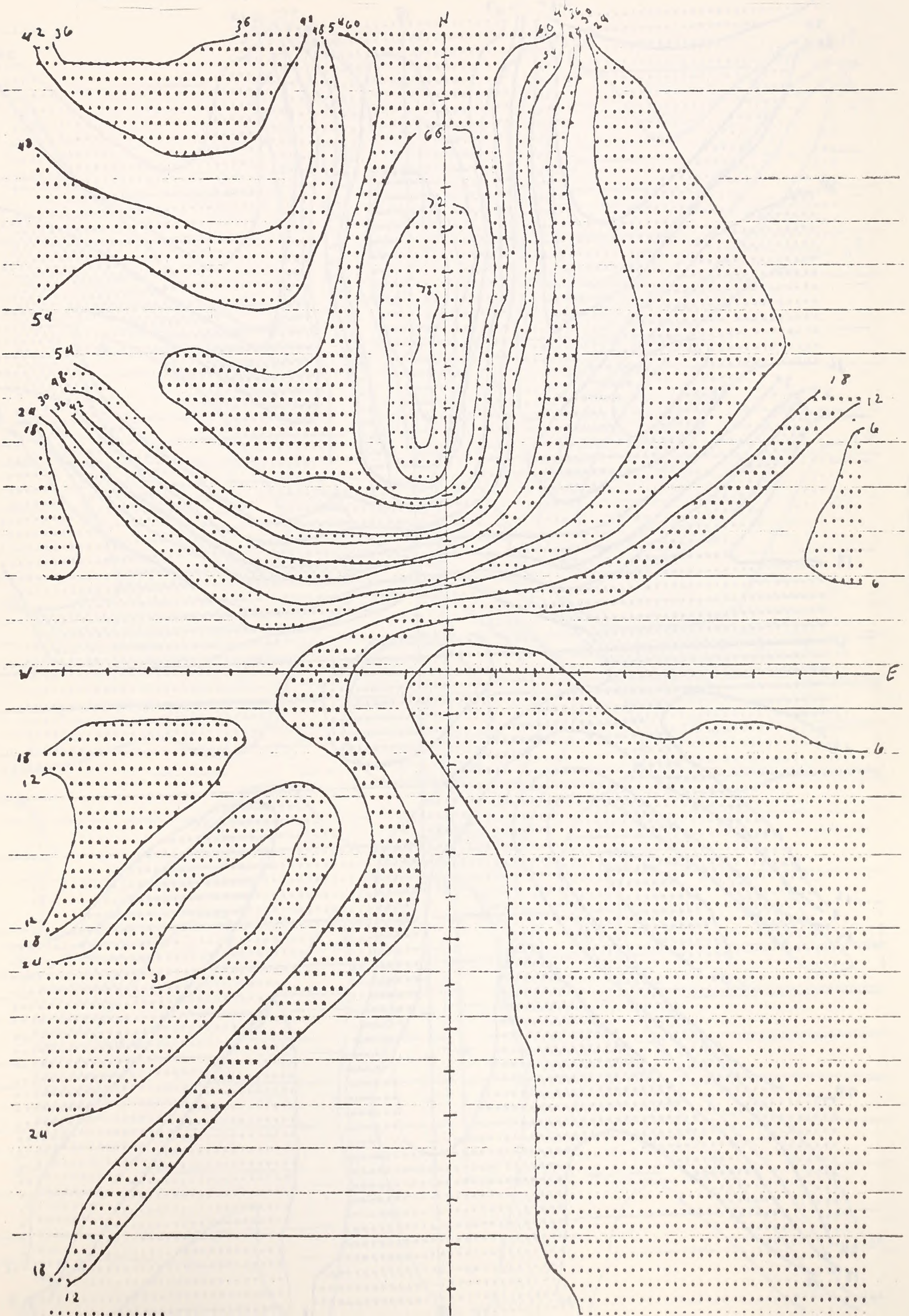


FIGURE II-30

Predicted October Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

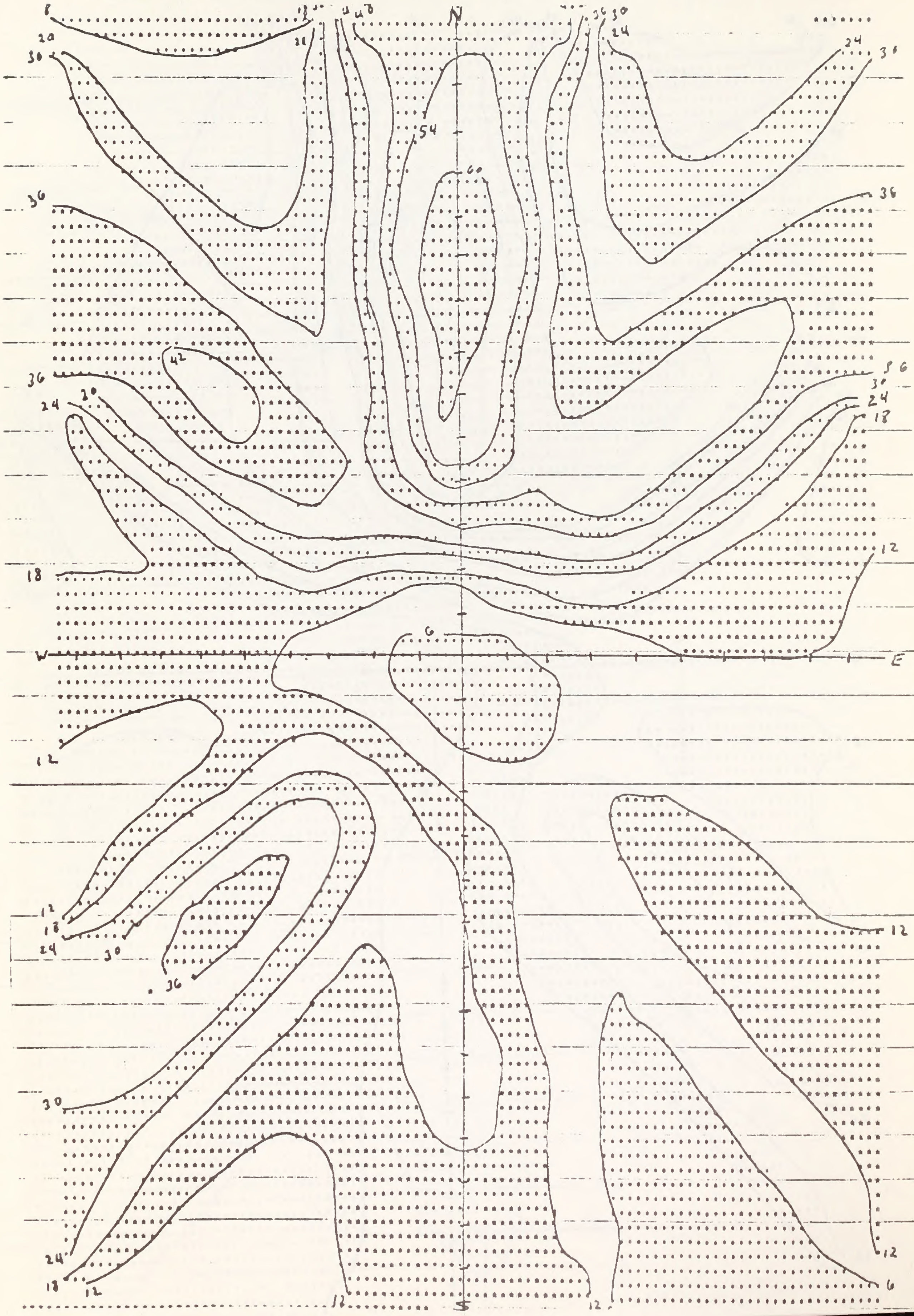


FIGURE II-31

Predicted November Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

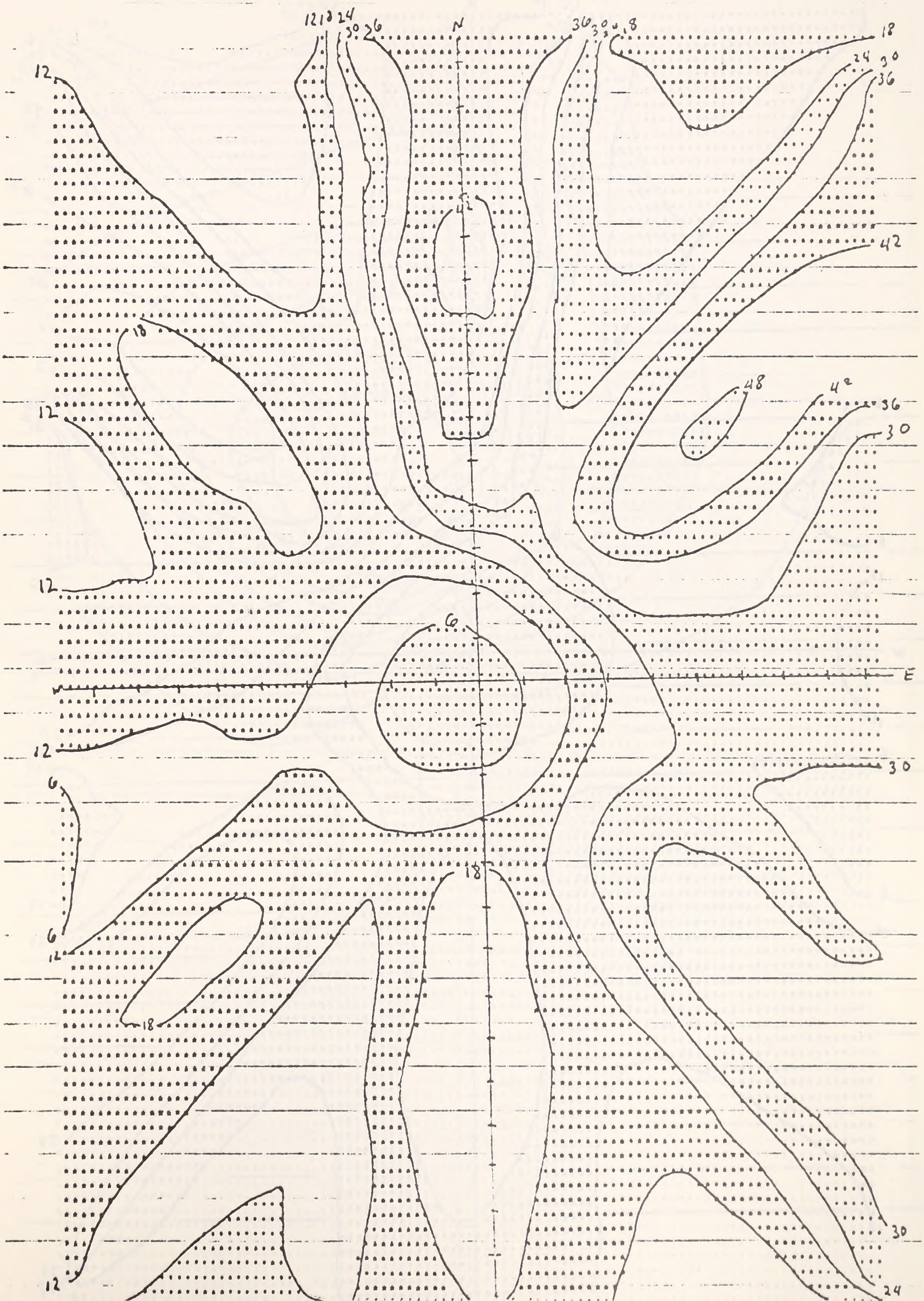
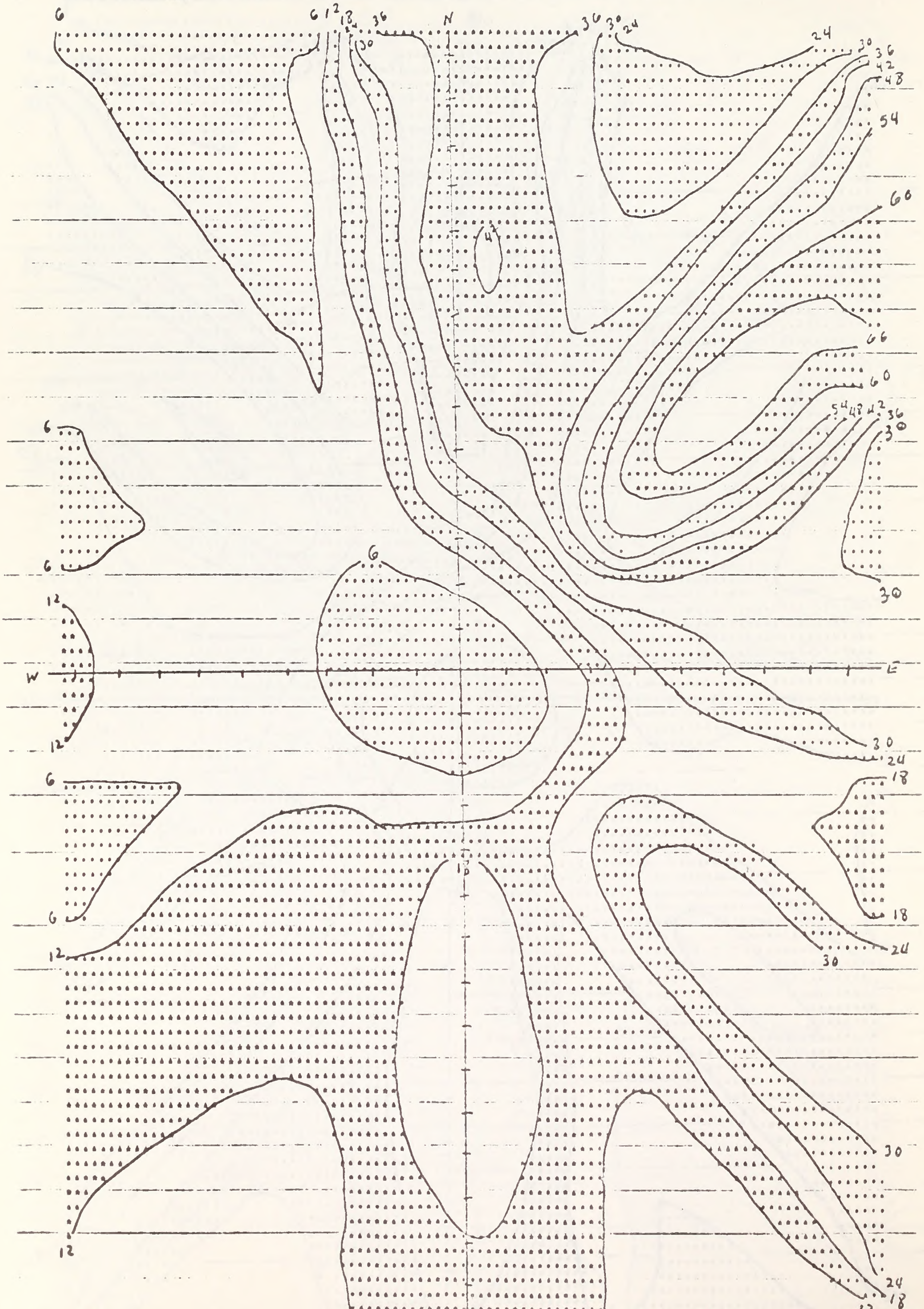


FIGURE II-32

FIGURE II-33

Predicted December Concentrations of Suspended Particulates in Environs of International Minerals Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions



Predicted June Concentrations of Suspended Particulates in Environs of AMAX Chemical Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

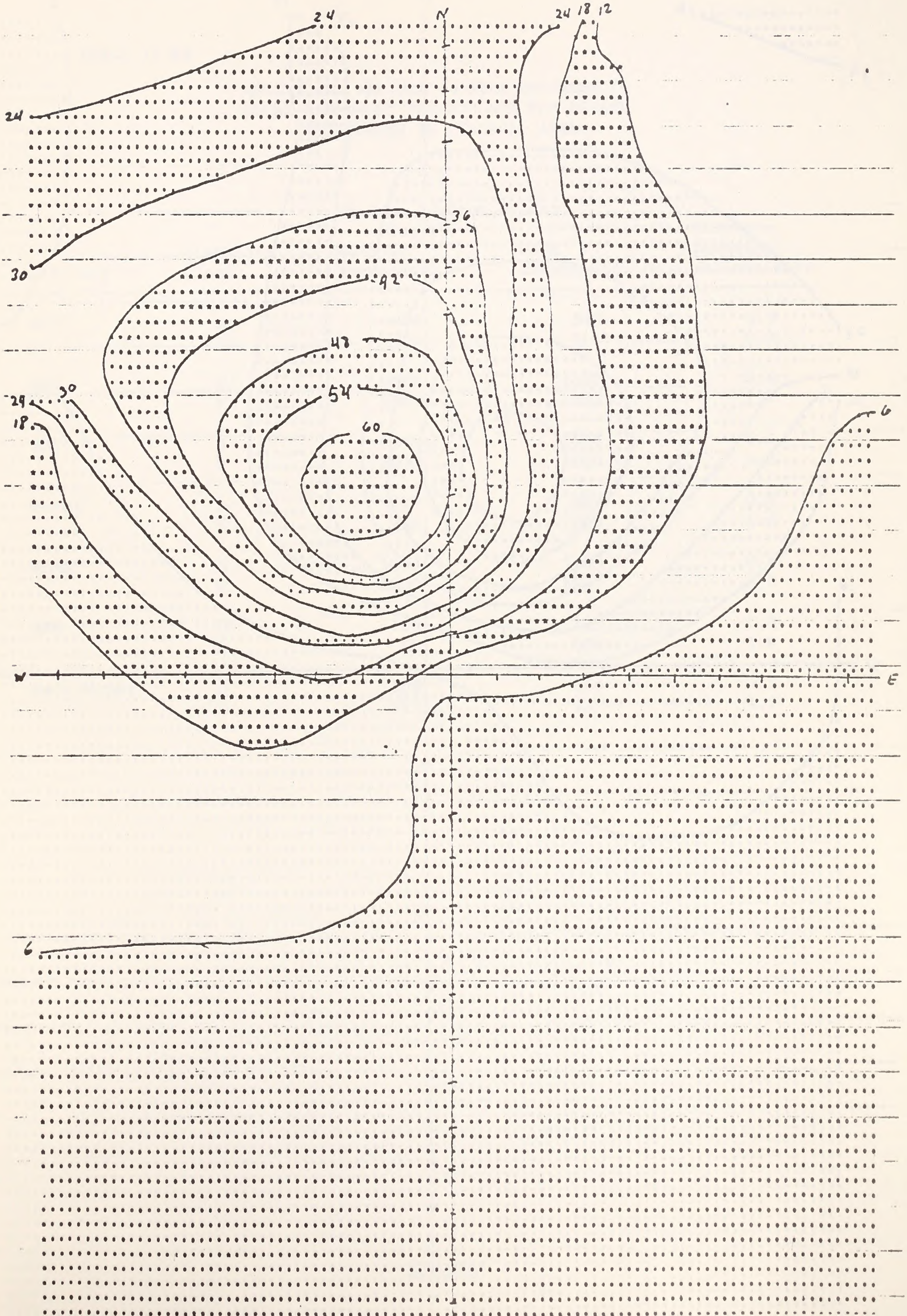


FIGURE II-34

Predicted June Concentrations of Suspended Particulates in Environs of Duval Corporation (isoconcentrations based on 30-day average ug/m^3) Intersection of Horizontal and Vertical Lines Represents Geographic Point of Refinery Emissions

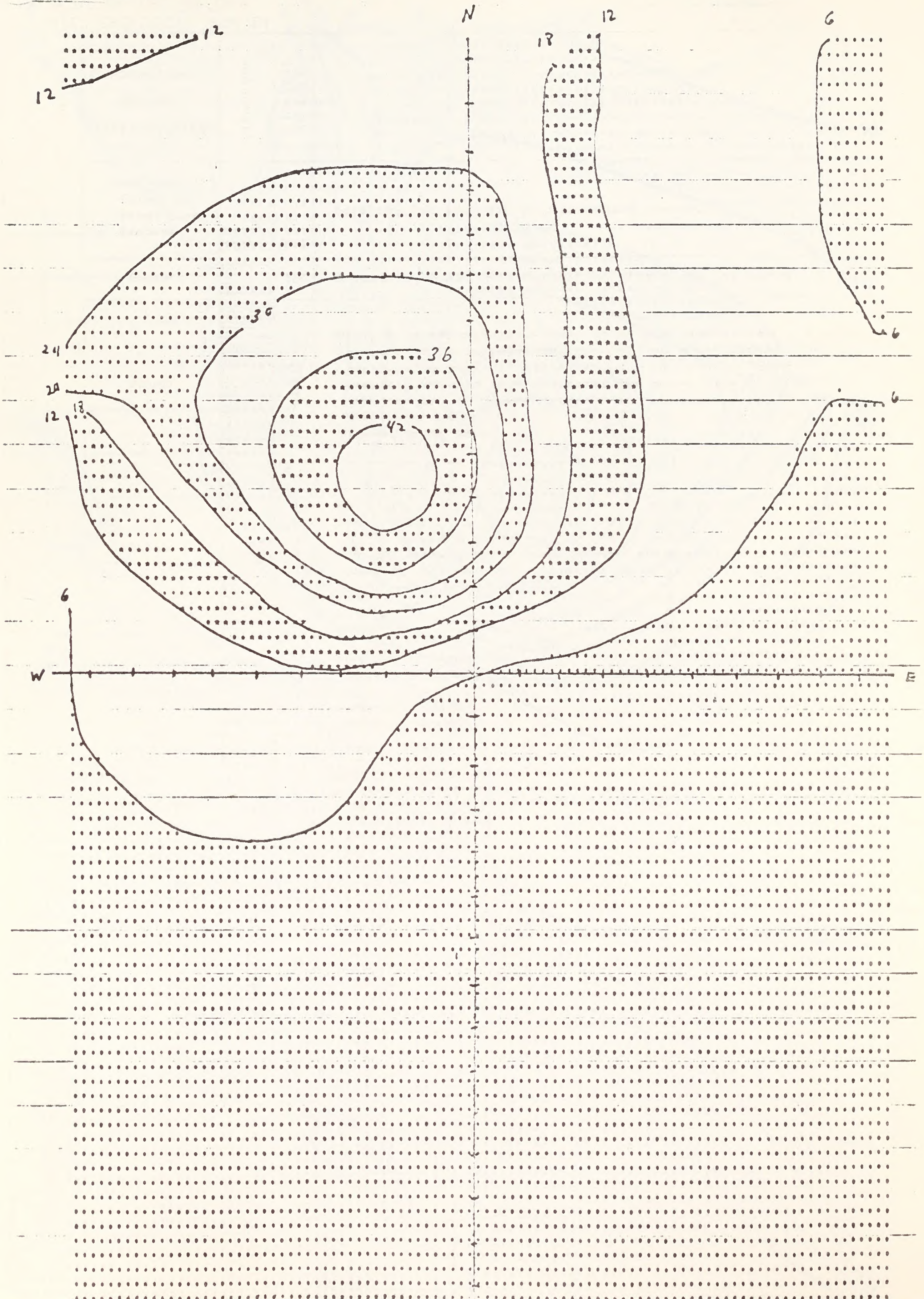


FIGURE II-35

TABLE II-49

CALCULATED MAXIMUM 24-HOUR AVERAGES OF TOTAL SUSPENDED PARTICULATS FOR POTASH REFINERIES IN CARLSBAD AREA

Refinery	Stability Class	Maximum 24-Hour Average (ug/m^3) Without Background	With Background	Distance Downwind (kilometers)
MCC	D	479	519	0.3
	F	575	615	0.8
PCA	D	1000	1000	0.4
	F	1000	1000	1.5
IMC	D	1000	1000	0.6
	F	1000	1000	2.0
Duval	D	823	863	0.5
	F	943	983	1.8
AMAX	D	1000	1000	0.5
	F	1000	1000	1.5
NPC	D	105	145	0.5
	F	98	138	1.8
Kerr-McGee	D	104	144	0.5
	F	117	157	1.7

TABLE II-50

TOTAL SUSPENDED PARTICULATES IN JUNE FOR SELECTED POTASH REFINERIES IN CARLSBAD AREA

Refinery	Peak Ground Level Concentration (ug/m^3) Without Background	With Background	Location of Peak (meters from refinery) North	West
PCA	120.0	160.0	250	150
IMC	117.0	157.0	450	250
AMAX	71.8	111.8	350	150
Duval	48.7	88.7	350	150

h. Current mine environment regulations.

(1) The New Mexico State Inspector of Mines Department, located at 505 Marquette N. W., Room 1103, Albuquerque, New Mexico, operating under a state plan of agreement with the Mining Enforcement and Safety Administration of the federal government, is charged with the responsibility of enforcement and inspection of health and safety in the potash mines. The Federal Mining and Inspection Act is in force until superceded by State law. This Joint Powers Agreement Act is authorized by Article 22, para. 3 of the New Mexico statutes. The State of New Mexico has adopted the threshold limit values of physical agents recommended by the American Conference of Government Industrial Hygienist. Mining Laws of the State of New Mexico are covered in Chapter 63 of Volume 9 of the State Statutes. Article 31 is the Mining Safety Act which is composed of sections 63-31-1 to 63-31-15. Section 63-31-6 of the article gives power of enforcement to the State Inspector of Mines Department. Other New Mexico laws pertaining to mining are; 63-26-6, Air Unfit for Workers; 63-28-11, Dust in Metal Mines; and 63-28-12, Dust in Mills, Ore Houses, and Treatment Plants.

The federal agency working in conjunction with the state is the United States Department of Interior, Mining Enforcement and Safety Administration, Metal and Non-Metal Mine Health and Safety, South Central District, located at 1100 Commerce Street, Dallas, Texas. Metal and non-metal mine health and safety standards are promulgated by the Secretary of Interior under the Federal Metal and Non-Metal Mine Safety Act (Public Law 89-577) and administered by the Mining Enforcement and Safety Administration (MESA). Exerpts from 30 CFR Chapter 1 Part 57 are listed below:

57.5-1 The exposure to airborne contaminants (TWA) shall not exceed, on the basis of a time weighted average, the threshold limit values (TLV) adopted by the American Conference of Governmental Industrial Hygienists, as set forth and explained in the 1973 edition of the Conference's publication, entitled "TLV's Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1973," pages 1 through 54, which are hereby incorporated by reference and made a part hereof.

57.5-2 Mandatory. Dust, gas, mist, and fume surveys shall be conducted as frequently as necessary to determine the adequacy of control measures.

57.5-3 Mandatory. Holes shall be collared and drilled wet, or other efficient dust-control measures shall be used when drilling non-water-soluble material. Efficient dust-control measures shall be used when drilling water-soluble materials.

57.5-4 Muck piles, haulage roads, rock transfer points, crushers, and other points where dust is produced in amounts sufficient to cause a health or safety hazard should be wetted down as often as necessary, unless the dust is controlled adequately by other methods.

57.5-5 Mandatory. Control of employees exposure to harmful airborne contaminants shall be, insofar as feasible, by prevention of contamination, removal by exhaust ventilation, or by dilution with uncontaminated air. However, where accepted engineering control measures have not been developed or when necessary by the nature of the work involved (for example, while establishing controls or occasional entry into hazardous atmospheres to perform maintenance or investigation), employees may work for reasonable periods of time in concentrations of airborne contaminants exceeding permissible levels if they are protected by appropriate respiratory protective equipment. Whenever respiratory protective equipment is used, a program for selection, maintenance, training, fitting, supervision, cleaning, and use shall meet the following minimum requirements:

(a) Mining Enforcement and Safety Administration approved respirators which are applicable and suitable for the purpose intended shall be furnished, and employees shall use the protective equipment in accordance with training and instruction.

(b) A respirator program consistent with the requirements of ANSI Z88.2-1969, published by the American National Standards Institute and entitled "American National Standards Practices for Respiratory Protection ANSI Z88.2-1969," approved August 11, 1969, which is hereby incorporated by reference and made a part hereof.

(c) When respiratory protection is used in atmospheres immediately harmful to life, the presence of at least one other person with backup equipment and rescue capability shall be required in the event of failure of the respiratory equipment.

UNDERGROUND ONLY

57.5-15 Atmospheres in all active areas should contain at least 20 percent oxygen.

57.5-50 Mandatory. (2) No employee shall be permitted an exposure to noise in excess of that specified in the table below. Noise level measurements shall be made using a sound level meter meeting specifications for type 2 meters contained in American National Standards Institute (ANSI) Standard S1.401971, "General Purpose Sound incorporated by refernece and made a part hereof, or by a dosimeter with similar accuracy.

Table II-51

PERMISSIBLE NOISE EXPOSURES

Duration per day, hours of exposure:	Sound level dBA, slow response:
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
½	110
¼ or less	115

No exposure shall exceed 115 dBA. Impact or implusive noises shall not exceed 140 dB, peak sound pressure level.

(b) When employees' exposure exceed that listed in the above table, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce exposure to within permissible levels, personal protection equipment shall be provided and used to reduce sound levels to within the levels of the table.

i. Enforcement procedures utilized to assure compliance with regulations.

Enforcement procedures utilized to assure compliance with regulations consist of unannounced inspections as provided by section 63-4-8 of the New Mexico laws, and section 4 of the Federal Metal and Non-Metal Safety Act (80 Stat. 772) for MESA. Since New Mexico is under a state agreement plan, inspections are usually in conjunction with MESA officials. Most citations for violations are issued by the state rather than the federal agency when the violation is covered by state law.

The state dust inspections consist of checking severe dust concentrations that exist in several working areas of the mine. The evaluation of dust concentrations with an Mine Safety Appliance (M.S.A.) gravimetric sampler determines the airborne respirable* fraction in the breathing zone of the working personnel.

Federal dust inspections utilize standard Mine Enforcement and Safety Administration techniques for total dust. This consists of sampling the breathing zone of various employees while they are performing their routine duties. Direct reading field test instruments are used to measure carbon monoxide and nitrogen dioxide concentrations in the mine air during an inspection. Mine air samples are collected in vacuum bottles during an inspection and are analyzed for percent by volume of carbon dioxide, oxygen, methane, carbon monoxide and nitrogen. Air for ventilation is considered to be of satisfactory quality when it contains at least 20.0 percent oxygen, not more than 0.5 percent carbon dioxide, and no harmful quantities of noxious gases. The threshold limit values for carbon monoxide is 0.005 percent or 50 ppm and for nitrogen dioxide it is 5 ppm. The percentage of nitrogen can be determined by subtracting the sum of the reported values from 100.00. The principal hazard investigated during health and safety inspections is employee exposure to nuisance dust. Threshold Limit Values (TLV's)

*Respirable fraction-fraction of total dust ranging from 0.1 to 10.0 microns in size.

for nuisance dust used in evaluating the results of surveys are set forth in the 1973 edition of the ACGIH publication entitled "TLV's for Chemical Substances and Physical Agents in the Work Environment." Excursions above the listed TLV's shall not be of a greater magnitude than is characterized as permissable by the ACGIH. A TLV of 10 mg/m^3 of total dust with less than 1 percent quartz content is recommended for nuisance dusts. Langbeinite and sylvite dusts are hygroscopic and generally contain less than one percent quartz.

To determine if the standards are exceeded, the time weighted average (TWA) is calculated using the formula below. The TWA is then compared with the TLV of 10 mg/m^3 to determine if the standard is being exceeded.

$$\text{TWA } (mg/m^3) = \frac{\text{Net Weight Dust (mg)}}{\text{Flow Rate (liters/min)} \times \text{Time(min)} \times 1\text{x}10^{-3}}$$

The noise inspection consists of a sound level survey on the different types of machinery and equipment in the mine and of determining the noise levels in the working environment of the employees. Noise measurements are made with a General Radio Company Model No. 1565-A sound level meter, U. S. Bureau of Mines approval No. 2G-2262. All readings are measured on the "A" weighting network slow response. Noise level readings are taken as near as possible to the equipment and machine operators position. A time-weighted exposure is obtained by questioning the employees and supervisors to determine the location and length of time spent at each location by the employees during an 8-hour shift. Violations of regulations or standards that are discovered by the inspectors and the length of time needed to abate the hazards are discussed with the employer. The inspector reports the violation to the appropriate state or federal agency which will then issue a state notice or federal citation to the employer. The notice or citation describes the provision of the federal or state regulation alleged to have been violated. The notice also states the length of time for abatement of the violation. Failure to correct the violation within the set time will result in a civil penalty. The type of penalty or action assessed is dependent upon the seriousness of the violation and the respective state or federal guidelines.

j. Existing environmental conditions of the mines.

All underground equipment, with the exception of jeeps and service vehicles, are electric powered. The jeeps and service vehicles are powered by diesel engines. Maintenance shops for sharpening and grinding bits are located underground. Environmental control measures include various ventilation systems by which fresh air sweeps through the mine passages to prevent accumulation of diesel combustion gases and/or formation gases. At the operating face, additional ventilation fans and vent bags are used to direct fresh air toward the machine operator to control respirable dust concentrations. At times moisture is also used to control dust.

A review of inspection records from MESA and the State Inspector of Mines indicates that the TLV's for nuisance dust was equaled or exceeded in the following job classifications.

Table II-52

NUISANCE DUST INSPECTION RECORD

JOB CLASSIFICATIONS	Dust Concentration mg/m^3* Average	Range
Driller	39.5	11.32 - 113.27
Undercutter Operator	28.05	14.24 - 40.19
Loader Operator	28.9	10.03 - 124.37
Shot Firer	26.6	15.56 - 37.72
Roof Bolter	47.6	10.25 - 66.71
Shuttle Car Operator	23.7	18.28 - 29.09
Station Tender (Dumping Area)	105.6	76.97 - 134.09
Belt Walker	55.6	12.35 - 149.15
Conveyor Cleaner	35.4	10.49 - 74.27
Clean Up Areas	100.8	100.8
Ram Car Operator	15.95	12.40 - 19.28
Powder Man	16.74	11.7 - 28.51

*milligrams per cubic meter

In most of these areas it was observed that respirators were not being worn. In one case it was remarked that respirators were not being furnished. In the majority of the cases where respirators were being used, they were not the approved type.

Inspection records indicated two areas where exposure to high level noise was occurring; (1) Cutter area, the duration time varied from 2½ to 6 hours and exposure level was 94-104 (dB) and (2) Maintenance Shop, bit sharpening or grinding, with the duration time up to 6 hours and exposure level at 92-96 (dB). Hearing protection devices were not being worn by operators. There were several areas where 90 (dB) was being exceeded. However, exposure times at the level was reported to be not in excess of the standards. Exposure times were obtained from employee and supervisor estimates of how much time was spent at that job during an 8 hour working day.

k. Current Refinery In-Plant Environmental Regulations.

The Occupational Health and Safety Act, Chapter 63, laws of 1972, Section 59-14-4, of the State of New Mexico established the State Occupational Health and Safety Agency. The agency is the designated state agency for all purposes under the federal Occupational Safety and Health Act of 1970, and may take all action necessary to secure the state the benefits of that legislation.

The state Occupational Health and Safety Act and regulations promulgated under it do not apply to the activities of an employer or his employees if the activities are subject to the jurisdiction of and are regulated by:

a. the State Inspector of Mines under the provisions of Chapter 63, NMSA 1953; or

b. any federal agency, except the Unites States Department of Labor acting under the provisions of the Occupational Safety and Health Act of 1970 (84 Stat. 1590)

Standards applicable to potash refineries in New Mexico under the state Occupational Health and Safety Act are currently the same as the federal standards in the Federal Register, (Part 1910 - Occupational Safety and Health Standards). The particular sections of interest are 1910.93 Air Contaminants, and 1919.94 Ventilation and 1910.95

Occupational Noise Exposure. The values for nuisance dust and noise are summarized below:

Table II-53

NUISANCE DUST VALUES

INERT OR NUISANCE DUST	8-hr. time Weighted average exposure limit
Respirable fraction	5 mg/m^3
Total Dust	15 mg/m^3

An employee's exposure in any 8-hour work shift of a 40 hour work week shall not exceed the 8-hour time weighted average (TWA) limit given. The cumulative exposure for an 8-hour work shift shall be computed as follows:

$$E = \frac{C_aT_a + C_bT_b + \ldots C_nT_n}{8}$$

where E is the equivalent exposure for the working shift. C is the concentration during any period of time (T) where the concentration remains constant. (T is the duration of exposure in hours at the concentration C.) The permissible noise exposures for refinery operation are the same as those for underground operations. See Table II-51, page 109.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: $C_1/T_1 + C_2/T_2 \ldots C_n/T_n$ exceeds unity, then, the mixed exposure should be considered to exceed the limit value. "C" is the exposure time at a specified esposure level, "T" is the time permitted at a specified level taken from Table II-51, page 109 and sub 1 is a specific exposure level. Exposure to implusive or impact noise should not exceed 140 dB peak sound pressure level.

The right of entry, inspection complaints, consultation and notification by state officials is authorized by 59-14-9 of the Occupational Health and Safety Act. Enforcement and penalties are authorized by 59-14-16 and 15-14-23 respectively.

1. Existing Environmental Conditions in the Refineries.

A review of inspection records from MESA and the State Inspector of Mines (Table II-54) indicates that the TLV for nuisance dust was equalled or exceeded in the following refinery areas and job classifications, associated with those areas. Table II-55 summarizes occupational areas in potash refineries where noise level limits are equaled or exceeded.

TABLE II-54

SUMMARY OF OCCUPATIONAL AREAS IN POTASH REFINERIES WHERE NUISANCE DUST LIMITS ARE EQUALED OR EXCEEDED

General Area	Specific Area	Job Classification	Dust Conc. TWA-Range	TWA* Average
Raw ore storage	Ore dump	Ore unloader	10.33	10.33
Impactor/ crusher building	Hammer mill	Ore runner	98.18	98.18
		Mill laborer	146.27	146.27
Ore screening plant	Rescreening hopper	Laborer clean-up	137.17	137.17
Refinery Mill Building	Crushing mill	Laborer (mucking)	75	75
		Control room Operator	12.46-19.79	16.12
	Dryer	Operator	82.63	82.63
	Product screening area	Laborer clean-up	56.24-130.81	103.99
	Compactor area	Operator	20.42	20.42
		Laborer clean-up	64.99	64.99
	Dispatch Area	Dispatcher	10.61	10.61

TABLE II -54 continued

SUMMARY OF OCCUPATIONAL AREAS IN POTASH REFINERIES
WHERE NUISANCE DUST LIMITS ARE EQUALED OR EXCEEDED

General Area	Specific Area	Job Classification	Dust Conc. TWA-Range	TWA* Average
Warehouse	Warehouse	Front-end loader operator	81.72	81.72
		Mechanic	24.16	24.16
		Slusher operator	17.41-29.94	23.67
Chemical Plant	Chemical plant	Laborer clean-up	10.36	10.36
	Plant reaction circuit	Operator	26.20	26.20
Bagging plant	Bagging machine	Operator	11.69-98.75	55.22
Various areas throughout	Various machinery	Maintenance Mechanic	10.80-118.02	42.2
		Welder	13.79	13.79

* Time Weighted Average

TABLE II-55

The inspection records indicate that the TLV's for noise were equaled or exceeded in the following areas:

SUMMARY OF OCCUPATIONAL AREAS IN POTASH REFINERIES
WHERE NOISE LEVEL LIMITS ARE EQUALED OR EXCEEDED

General Area	Specific Area	Equipment or Machine	Man hours	dBA
Raw ore storage	Railroad Grizzly	Car shaker	5½	107-108
	Control room		5½	96-102
	1st floor sulphate plant	Dryers	1	94-104
	Filter area	Ozark filters	Men work sporadically	96-103
Refinery mill	Screening Area	Screens & auger screws	"	92-97
		Vibrator Screens	"	106-108
	Flotation deck	2 sets flotation cells	6	90-92
	Granulator Area	10 Allis chambers granulator	6	90-100

TABLE II-55 continued

SUMMARY OF OCCUPATIONAL AREAS IN POTASH REFINERIES WHERE NOISE LEVEL LIMITS ARE EQUALED OR EXCEEDED

General Area	Specific Area	Equipment or Machine	Man hours	dBA
Chemical Plant	Concentration filter area	Blower for concentration	Men walk through periodically	100-108
Warehouse	Dumping area	Euclid dozer	5	104-108
Maintenance shops	Carpenter shop	Radial arm saw	1½	105-112
Power house	Generator area	6 Nordberg generators	8	94-98

As mentioned earlier, noise exposure duration times were estimated from employee and supervisor determinations. Due to the subjectivity of this approach it is probable that several other areas exist with hazardous noise exposures. As observed from inspection records, there were many machines and related equipment producing noise levels above 90 dB.

The mining and refining of potash has been regarded as a relatively healthy occupation. In the studies of the hazards of uranium mining in the U.S.A., potash miners from New Mexico were used as controls. A study of the mortality of potash miners in the U.S.A., by Waxweiler, Wagoner and Archer, resulted in the conclusion that they are not predisposed to respiratory, cardiac, or cerebrovascular diseases. A study of potash ore and its relationship to perforation of the nasal septum was done by Dr. Norman Williams on Canadian potash miners and mill workers in 1964. The results of this study indicated a prevalence of nasal septum perforations among 3.2 to 6.3 percent miners, particularly operators of continuous mining machines and shuttle cars. Two cases were seen in potash millers. One had never worked in the mine; he had worked in the mill dryer and compacting area for 1½ years, the nasal perforation occurring after 10 months exposure.

The first symptoms were irritation and soreness in excess of that usually associated with potash ore dust exposure. This would be followed by either or both discharge and bleeding; many noticed crusts in the discharge and few thought they could see nasal tissue. The end result was usually a clean perforation, 4 to 5 mm., of the lower part of the cartilaginous septum.

The two main constituents of potash ore are sodium chloride and potassium chloride, generally present in a ratio of 2:1. Also present in the ores are clays and some iron oxide. Traces of other metals including calcium and magnesium are present. Potassium chloride is highly toxic when its extracellular concentration rises even slightly above the normal level. It is therefore, possible that it is this specific effect rather than the hygroscopic action, which is responsible for perforation of the nasal septum of potash miners.

MESA officials conducted a walk-through industrial hygiene survey of a potash refinery for health hazards other than dust and noise. Although numerous chemical reagents are used in the production of potash products, none were observed to be a potential airborne hazard of a chronic or long term nature.

The handling of these chemicals in bulk quantities during transportation to and from storage, batch mixing, and filling reagent reservoirs will result in occasional airborne and skin contact exposures. This should be the general situation in all of the New Mexico potash refineries, since the present technology being used in the refineries is basically similar. Table II-56 summarizes MESA and State Inspection Records for the potash industry in the Carlsbad area.

TABLE II-56

SUMMARY OF MESA AND STATE INSPECTION RECORDS FOR THE POTASH INDUSTRY IN THE CARLSBAD AREA

Inspection Records Available at Time of Report	MESA Inspection Records				State Inspection Records			
	Mine		Mill		Mine		Mill	
	Dust	Noise	Dust	Noise	Dust	Noise	Dust	Noise
Duval						Dec. 72		Dec. 72
Nat. Potash	Mar. 75		Mar. 75					
AMAX	Mar. 75		Mar. 75		Mar. 74	Mar. 74	Mar. 74	Mar. 74
PCA	Jan. 75		Jan. 75	Jan. 75		Jan. 74		Jan. 74
Miss. Chem.	Mar. 75		Mar. 75					
IMC	Jan. 75		Jan. 75					
Kerr-McGee								

2. Land

a. Topography

The topography within the study area is quite varied. The elevations range from 2,950 feet at the Pecos River on the west, to 3,900 feet at Mescalero Ridge on the east. This rise in elevation of approximately 1,000 feet occurs over a distance of 40 miles. The general relief is attributed to dune fields and collapse features typical of a karst topography.

The eastern portion of the area is dominated by gently sloping to undulating and dunelike topography. The area between the sandy plains and the Pecos River includes some low mesa plains area, in which the gently sloping, smooth-lying surface is broken by only a few drainage depressions and very small basins and sinks. Steeply sloping escarpments and breaks often occur on the sides of mesas. The differences in local reliefs however, generally are not great and usually average less than 100 feet.

The study area slopes generally to the south and west. Nearly level to very gently sloping flood plains border many of the principal drainages. These occur in the valley bottoms of the Pecos River, as well as near a number of small, short, ephemeral streams.

b. Soils

Soils of the Carlsbad Potash Area are delineated into 6 soil groupings in this study and will be referred to as Groups I through VI. Appendix, A-8 contains a listing of individual soils identified by groups for the study area. These soils have developed under mixed shrub and grassland vegetation common to the semi-arid continental climatic conditions of the Southern Desertic Basin and Plain. As a result of prevailing climatic and vegetative conditions, many soils have developed with a light colored surface. Subsoil colors normally are light brown to reddish brown, but are often mixed with white lime accumulations, which result from limited, erratic rainfall and insufficient leaching. Most soils of the study area have developed from wind worked material of mixed origin and/or in old alluvium derived from sedimentary rocks. (See Map II-1 in back pocket of this report for locations of soils groups.)

(1) Group I Soils - Shallow Over Caliche

Soils of Group I are scattered somewhat uniformaly throughout the study area east of the Pecos River. These shallow soils have been continually worked by wind and occur on the landscape as nearly level to gently sloping and undulating uplands. Numerous playas or potholes dot the landscape throughout the area. Minor swales and depressions, as well as one to three foot high hummocks are common in this grouping. Small areas of steeply sloping lands on escarpments and breaks are also included. Although small areas of deeper soils may be interspersed throughout these soils, Group I is dominated by shallow soils which are typically underlain by fractured caliche which ranges from strongly cemented to indurated. A thin surface layer is characteristic of the soils, with angular caliche fragments common in the profile and comprising as much as 35 percent of the soil mass in the soil layers immediately above the underlying indurated caliche. These soils have developed in old alluvium from calcareous sedimentary rocks and/or in wind deposited sandy loams and sands on the uplands. These soils are subject to severe wind erosion if the plant cover is severely depleted. Reestablishment of desirable vegetation forage species is difficult because of high temperatures and undependable precipitation.

Photograph II-2 depicts the surface view of a typical Group I soil as found in the study area. This location is northeast of Kerr-McGee and shows exposed caliche fragments on the surface of an old pipe line right-of-way site which was constructed in the shallow soils.

Kimbrough and Upton soil series are samples of the loamy soils within Group I. Generally, the hazard of erosion is of minor consequence in these soils. However, where the soils are located in swales and depressions, they are subject to periodic flooding and are easily eroded by water if the vegetative cover has been seriously depleted. Reestablishment of vegetative species is difficult because of the arid climatic conditions. The soils are productive but have low water holding capacity and are, therefore, droughty. Usefulness is limited by shallowness over caliche (Standard Soil Survey, Eddy Area, 1971).

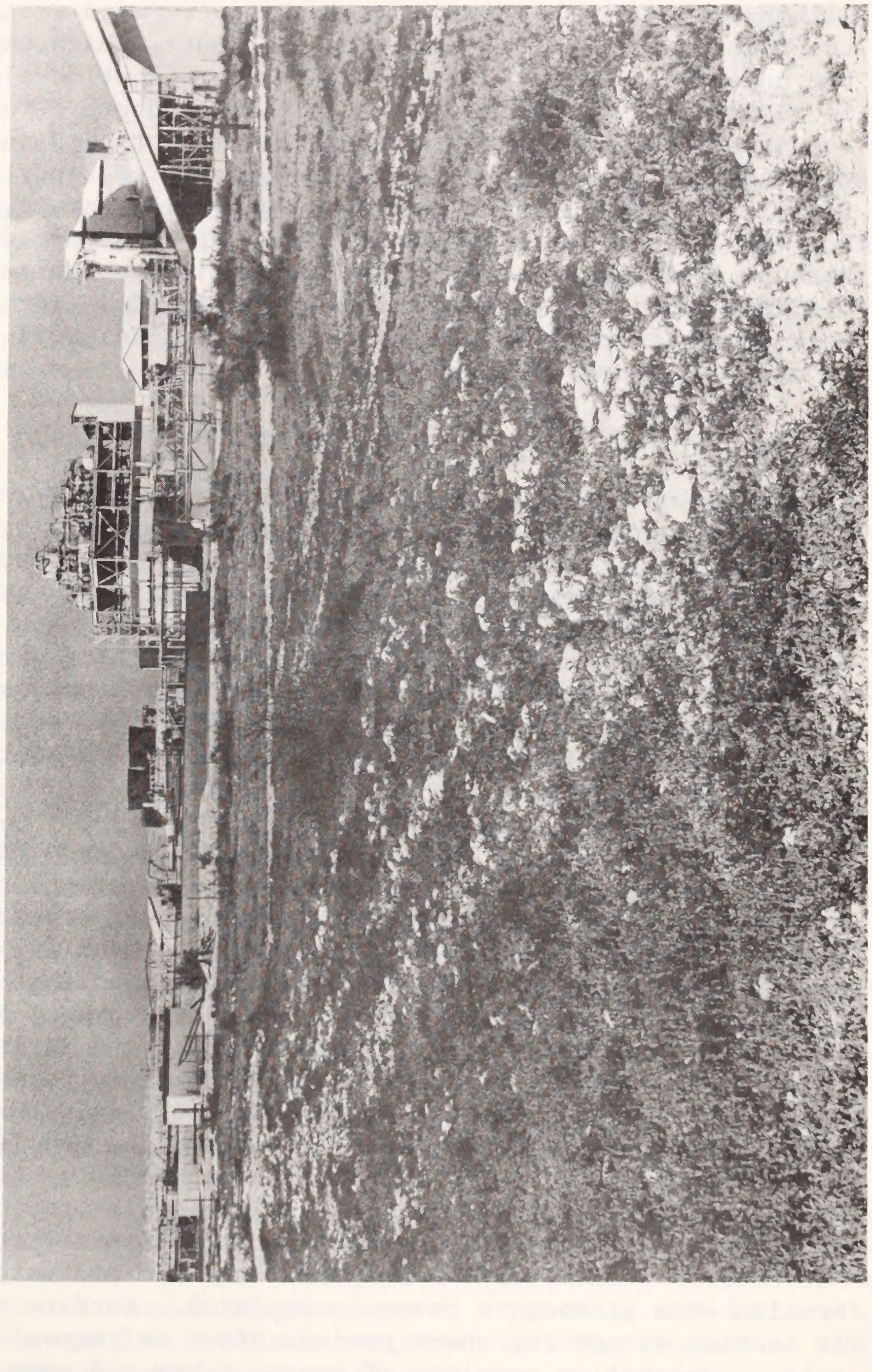


PHOTO II-2 Group I Soil

Simona, Tonuco and Maljamar are sandy soils identified within Group I. They are subject to severe wind erosion if the plant cover has been removed. Blowouts, which expose the underlying caliche layers are common. Root development is restricted by caliche layers at shallow depth. The soil requires management that will control wind erosion and maintain sufficient ground cover. Hummocks of sand, 1 to 3 feet high cover 20 to 40 percent of the soil surface. Permeability of these soils is rapid, but soils are droughty because of their low water holding capacity. Under existing climatic conditions, revegetation is difficult. (Standard Soil Survey, Eddy Area, 1971; Lea County, 1974; Soil Associations, Eddy County, 1970).

(2) Group II Soils - Shallow Over Gypsum

Widely scattered, discontinuous tracts of Group II soils are found throughout the study area. One area extends northeast from near Salt Lake on past the south side of IMC and lies east of Loving, New Mexico. Another extensive area extends northeast from Carlsbad, New Mexico, along the north side of Highway 62/180 and on by PCA operations. A third area is located between National Potash and Kerr-McGee and extends on to the east. Smaller areas contained in this grouping are also scattered along the eastern and extreme southern portion of the study area.

Group II soils are generally located on a landscape that is gently sloping to slightly undulating. Sink holes, not containing water, are common and normal travel across these soils may be difficult. The surface crusts readily and impedes seed emergence, with any surviving seedlings subject to damage by high winds. Shallow soils over gypsum and/or steep broken exposures of gypsiferous rocks and earths are typical of Group II. The surface is moderately permeable, but the underlying gypsiferous material is slowly permeable. Plant roots are limited by the salinity of the gypsiferous material which typically lies about 9 inches below the surface. These are well drained, saline soils that have developed in old alluvium derived from sedimentary rocks. The soil is unstable and susceptible to wind and water erosion when protective cover is depleted. Surface moisture is lacking except for short periods after infrequent heavy rains. Vegetation consists of sparse cover and good management must be exercised to maintain a cover of vegetation, as revegetation under present climatic conditions is difficult. (Standard Soil Survey, Eddy Area, 1971; Lea County, 1974).

Typical surface views of Group II soils are shown on Photograph II-3. This site is located west of the National Eddy ore loading shaft and is typical of shallow gypsum soils.

The individual soils of Group II are similar in characteristics, but may differ in depths to gypsiferous materials. Gypsum land, Gypsum Land-Cottonwood Complex, and Gypsum Land-Reeves Complex are soil series with gypsum materials at shallow depths of 9 to 14 inches. Cottonwood-Reeves, and Reeves-Reagan soil series have gypsum at moderate depths. Russler and Reagan-Upton soil series generally encounter gypsiferous materials at depths greater than 45 inches.

(3) Group III Soils - Deep Sand

Group III soils are dispersed throughout the entire study area as large, expansive areas. They are located on a landscape which is gently sloping, undulating and characterized by small hummocks and large coppiced sand dunes. These dunes have formed around woody plants, such as mesquite, and each windstorm alters the depth of the surface soil. The surface layer is thicker adjacent to the coppiced sand dunes as a result of this continued wind action. In other areas, the surface layer has been removed by erosion and the dry, slightly harder subsoil of fine sandy loam is exposed. They are typically deep, sandy soils that have developed in wind worked material of mixed origin and overlie sandy, calcareous, alluvial sediments. Their characteristic sandy composition subjects them to the prevailing wind and water erosion. The soils of this group lack surface water except for short periods after infrequent heavy rains. They retain nearly all the moisture that falls, but the surface layer has a low water holding capacity, so it may become droughty. The organic matter content for these soils is generally low. Permeability is rapid in the surface layer, but is moderately slow in the subsoil due to the more loamy texture present. The depth to a distinct layer of lime accumulation ranges from 36 to 60 inches. Roots are able to penetrate to a depth of 60 inches, or to the layer of lime accumulation. If the vegetative cover is seriously depleted, the erosion hazard becomes severe. The soils are difficult to revegetate once this plant cover is lost, because of the undependable precipitation in the area.

Photos II-4 through II-6 depict the surface view of a typical Group III soil in the study area. This site, located south

PHOTO II-3 Group II Soil

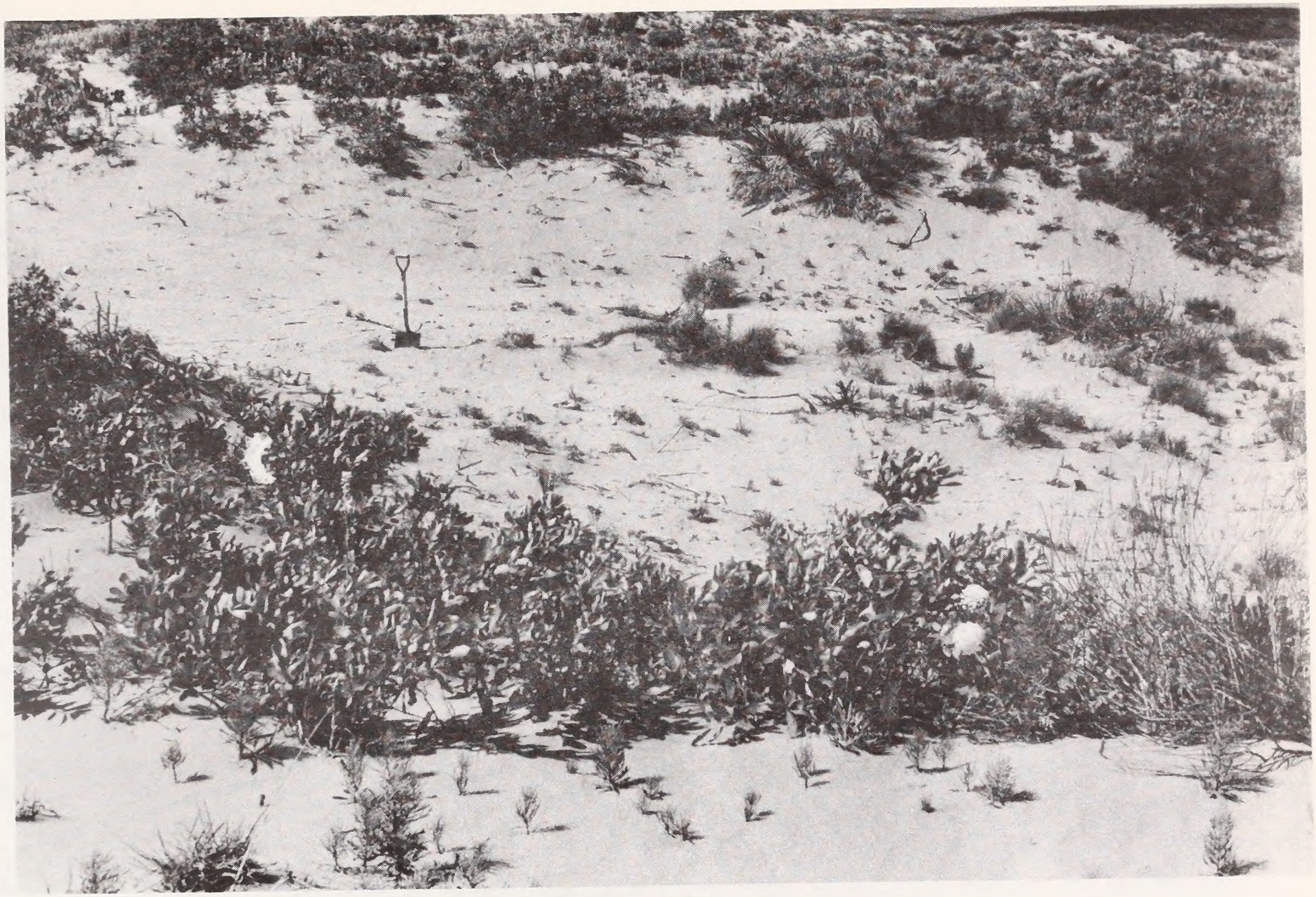


PHOTO II 4 Group III Soil

PHOTO II 5 Group III Soil

PHOTO II 6 Group III Soil

of the Duval refinery shows the characteristic dune land effect of this grouping.

The Berino soils may be slightly or moderately eroded under normal conditions, with the hazard of further erosion being severe if the vegetative cover is seriously depleted. In contrast with extreme conditions prevailing, Berino Dune land soils have already had serious erosional damage, with the soils altered to the extent that vegetative yield may be limited. The surface layer is thin, and little or no vegetation exists where the subsoil has been exposed. Good management is needed to maintain enough vegetation to check erosion. (Standard Soil Survey, Eddy Area, 1971; Lea County, 1974).

(4) Group IV Soils - Deep Loam

Soils within Group IV occur as small, widely scattered tracts throughout the study area. They are generally located on a nearly level to gently sloping landscape, with some soils occurring as alluvial fans. Characteristically, these soils are deep and loamy. The zone of lime accumulation varies, but is generally at 15 or more inches deep. They have developed in alluvium derived from upland sedimentary materials and/or wind and water deposited sediments.

Permeability of these loamy soils is moderate to moderately rapid, with runoff being slow to medium. Water intake of these soils is moderate and the water holding capacity throughout the profile is medium to high. The organic matter content is low and fertility is moderate. Most areas are slightly to moderately eroded, with a few deep gullies forming as a result of runoff from higher soils. Repeated deposition of soil material has altered the vegetative cover somewhat. Roots are able to develop to a depth of 20 to 60 inches, or to the strong lime zone. Because of the soil's position, its parent material, and the limitation of undependable precipitation patterns of the area, revegetation is difficult.

Group IV soils, which are deep with a high loam content, can also be identified as depressional areas and/or swales in the Study Area. Photograph II-7 depicts a surface view of these soils at a site located about three miles east of MCC's north shaft.

All of these soils are slight to moderately eroded by water. They are productive if a moisture supply is sufficient, but revegetation is generally difficult because

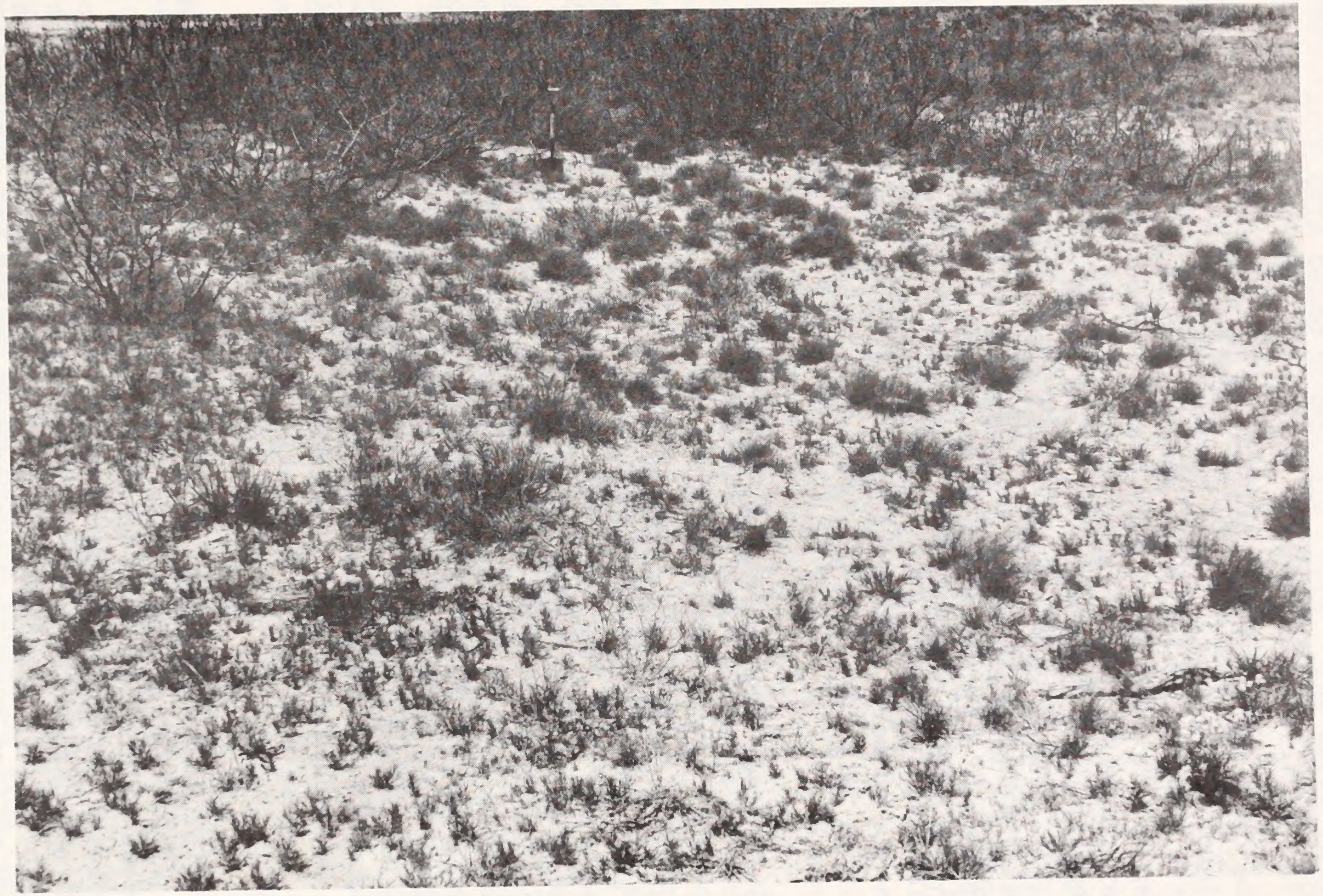


PHOTO II-7 Group IV Soil

rainfall is undependable under normal conditions. (Standard Soil Survey, Eddy Area, 1971; Lea County, 1974).

The Dev-Pima soils are subject to periodic flooding from higher lying soils. This series has gravelly loam surface, with loamy material being encountered about 15 inches depth. This is mixed with gravel and cobblestones, which may comprise 60 to 90 percent of the soil mass. Repeated deposition of soil material has altered the vegetative cover. Permeability is moderate above the gravelly material, but gravel may restrict the root zone. Pima soils are also subject to periodic flooding, however their textural composition varies in that they have a loamy surface with light clay loam to silty clay loam substratum which extends to 60 inches or more. The effective rooting depth of the vegetation is not restricted, so it may develop to 60 inches or more.

(5) Group V Soils - Moderately deep to deep over soft caliche

Soils of Group V are identified as small, discontinous tracts and are located almost entirely in Lea County within the study area. On the landscape, they occur in a nearly level to gently sloping position. These soils are well drained, having loam to clay loam subsoils which are characteristically high in lime content (soft caliche). They have developed in chalky stream or lake sediments, or as strongly calcareous, wind and water deposited sandy sediments, in shallow basins. The loamy surface layer ranges from 4 to 12 inches thick, with loam to clay loam subsoil being from 11 to 20 inches in depth. The substratum extends to a depth of 60 inches or more and generally contains a high content of lime.

Soil blowing is a moderate erosional hazard because of the loamy texture of the soils, but there is also a moderate to severe hazard for water erosion. If vegetative cover is depleted, adequate management is needed to control erosion and maintain a vegetative cover on the soils. The Midessa soils of this grouping, with a more loamy profile, have a slow surface runoff rate, with water intake being moderate to rapid. Water holding capacity is medium. Roots are able to penetrate to a depth of 20 to 40 inches where they may contact a strong lime zone. Soil blowing on these soils is a moderate hazard.

Mobeetie soils have more sand in the profile, with the permeability rate being moderately rapid. The water holding capacity of the soil is medium. No restrictive layer exists, so roots are capable of penetrating to 60 inches or more in depth. Soil blowing on these soils is a moderate hazard with water erosion a moderate to severe hazard due to the presence of sand in the soil.

The soils of this grouping are capable of production if sufficient moisture is available. For successful revegetation, this can be a limiting factor. Care must be taken to control the removal of excess surface soil, as the strong lime zone (soft caliche) may be encountered at a relatively medium depth (10 to 40 inches). (Standard Soil Survey, Lea County, 1974; Soil Associations, Lea County, 1970).

(6) Group VI Soils - Playa

Playas, which are identified as Group VI in this study, are typical of playas found throughout arid and semi-arid regions. They may be found in all parts of the study area, ranging from an acre or two in size, to a few that may be 640 acres or more. These are flat basins or sump areas, located on the nearly level uplands or on the floor of the desert valleys. They may contain water of shallow depth for short periods at infrequent intervals. The water-laid sediments of the playas are generally fine textured, with a high silt and clay content. They are highly charged with salts or alkalis, are subject to periodic overflow and are typically devoid of vegetation other than a few annual forbs. (Standard Soil Survey, Lea County, 1974; Soil Associations, Lea County, 1970).

c. Geology of the Potash Study Area

The study area in Eddy and Lea Counties, New Mexico contain large and important quantities of fertilizer and energy producing mineral resources, as well as tremendous resources of common salt (halite). Some earth materials in the area are suitable for use as aggregate in the construction industry. There are some noncommercial occurrences of native sulfur in southeastern New Mexico which receive attention from the minerals industry from time to time, but will not be discussed further because little is known of the details of occurrence, and most occurrences are outside the study area. Commercial deposits of potassium-bearing rocks amenable to mining by underground methods have been the chief source of the national potash fertilizer supply for many years. Oil and gas have been produced from southeastern New Mexico since 1909, although the first major discovery was in 1928 near the town of Hobbs in Lea County.

The geology discussed in this report is taken essentially from Brokaw and others (1972), unless otherwise noted. The list of selected references in the report by Brokaw and others contains most of the more pertinent publications that deal with the geology of the area. Only brief descriptions of the structure and stratigraphy are given here.

(1) Structural features

The rocks in the general vicinity of the potash mines are, for the most part, little deformed. They are related to three broad geologic structures, namely the northern Delaware Basin, the Northwest Shelf north and west of the basin, and the Central Basin Platform to the east (See Map II-2).

The northern part of the Delaware Basin is a broad asymmetrical southward plunging trough. Its axis is in central Lea County, roughly parallel to the Central Basin platform. The eastern slope of the trough rises rapidly to the platform, whereas the western slope is much gentler. The buried front of the Capitan reef, which trends eastward through the middle of the potash mining, area is generally taken as the northern boundary of the Delaware Basin; as far Permian Guadalupian rocks are concerned (Kelly, 1971, p. 39).

(2) Stratigraphy

Sedimentary deposits ranging in age from Ordovician to Quaternary, have a maximum thickness of about 20,000 feet in the deepest part of the northern Delaware Basin in southern Lea County (Brokaw and others, 1972, p. 14). Representative thicknesses and lithology of individual rock units of the Delaware basin are given in Figure II-36, a generalized stratigraphic column from the Gnome test site (Sec. 34, T. 23 S., R. 30 E.). Map II-3 shows the distribution of rocks that are either near the surface under a thin cover of Quaternary sediments or crop out.

The pre-Permian units of the Delaware Basin have essentially the same character as the rock units of that age that extend over the Northwest Shelf and the Central Basin Platform.

DEPARTMENT OF THE INTERIOR
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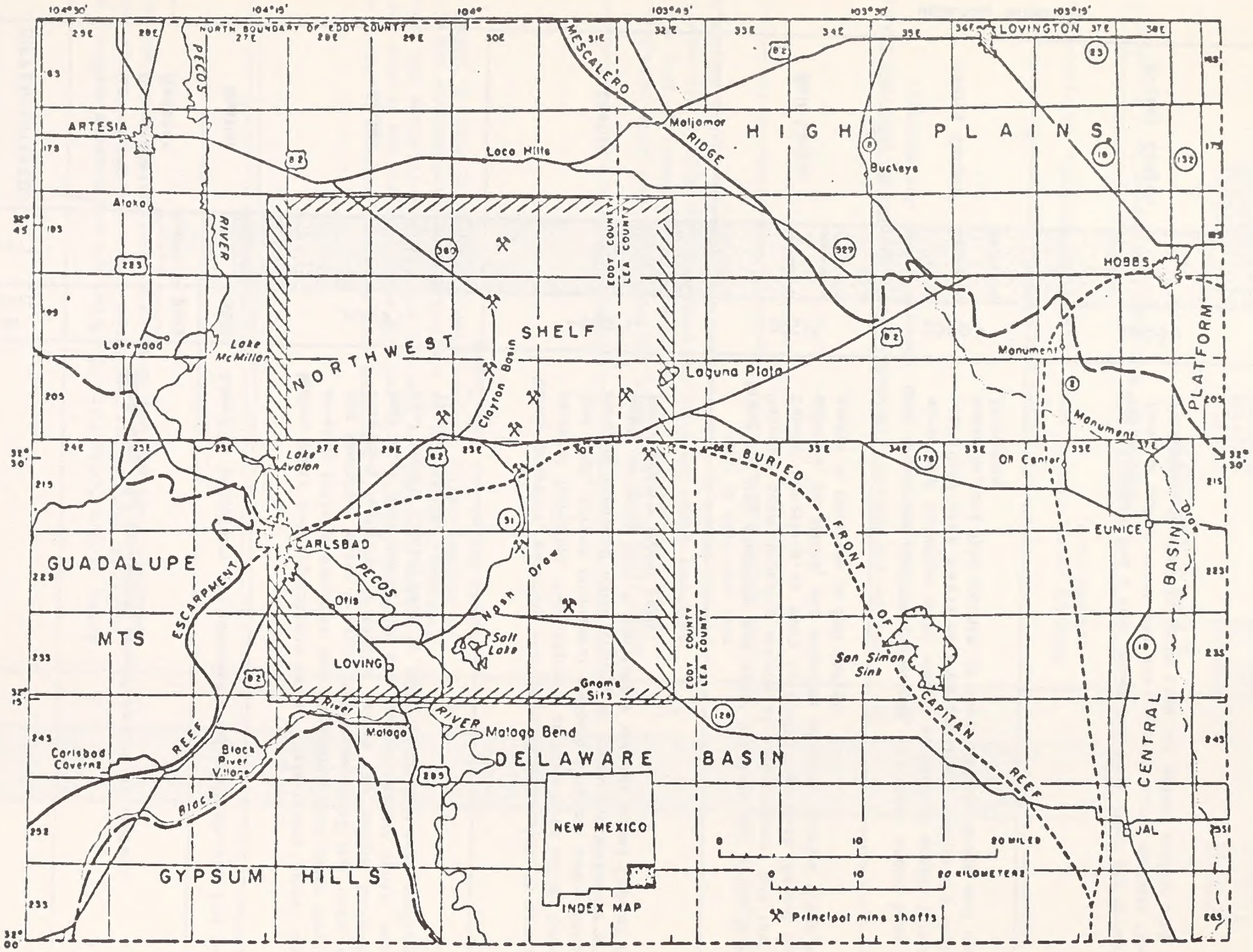


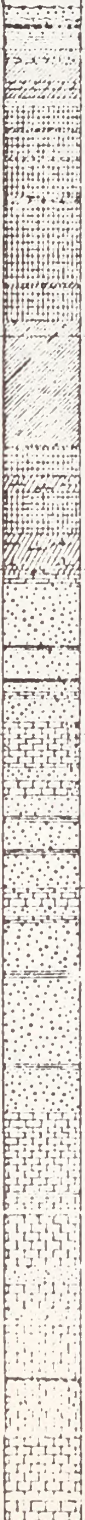
U.S. Geological Survey
OPEN FILE REPORT
This map is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

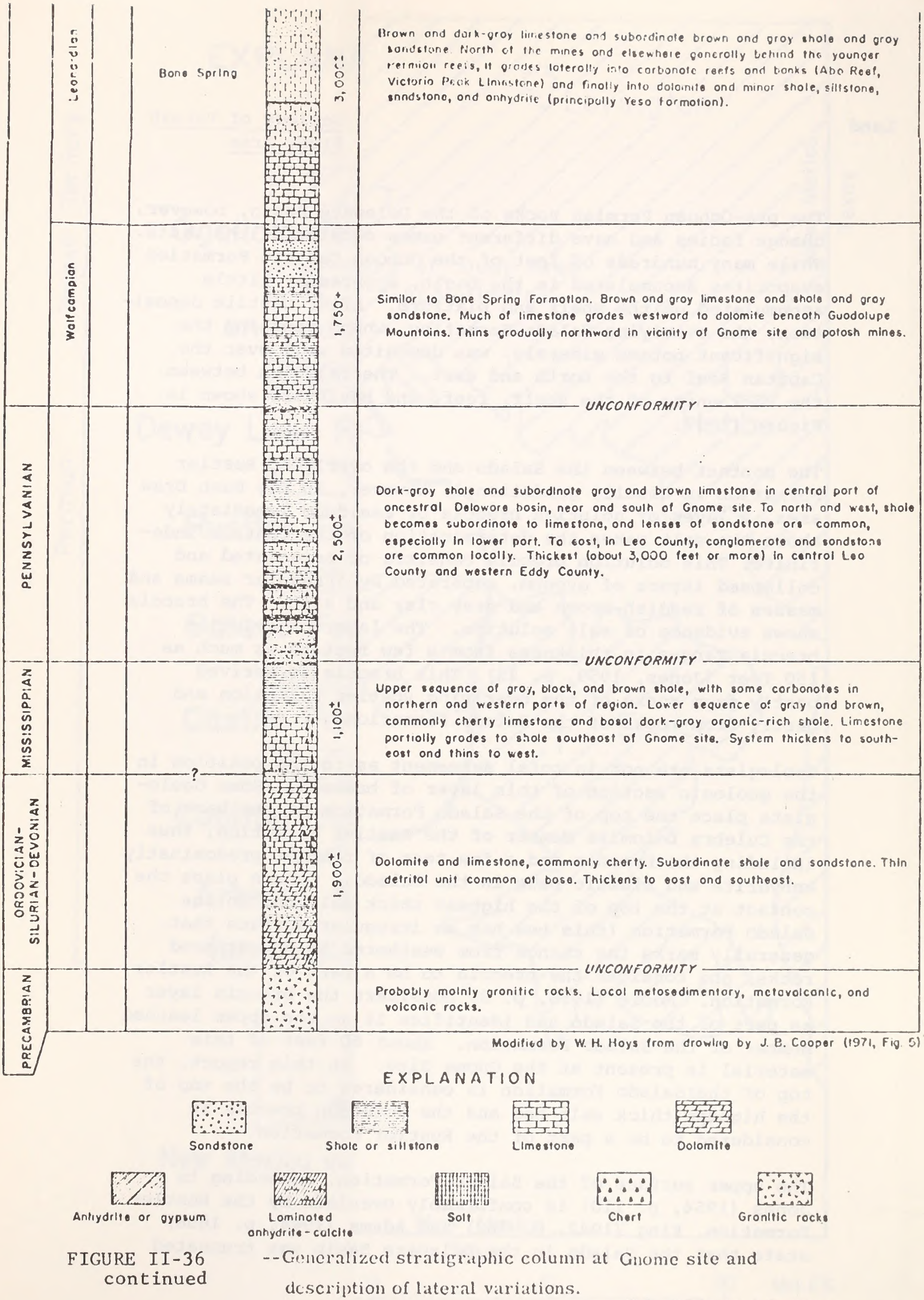
MAP II-2 Vicinity of the potash mines, southeastern New Mexico. Northern boundary of Delaware Basin is defined by buried front of Capitan Reef.

FIGURE II-36

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

OPEN FILE--1972
BROKAW AND OTHERS
CARLSBAD POTASH,
NEW MEXICO

SYSTEM	SERIES	GROUP	FORMATION (WHERE DIFFERENTIATED)	LITHOLOGY	THICKNESS, IN FEET	DESCRIPTION
QUATERNARY			Dune sand, Gatuna, and Dewey Lake Redbeds		290	Sand, clay, and sandstone, unconformable on redbeds.
PERMIAN	Ochoan		Rustler		360	Anhydrite or gypsum and subordinate salt, dolomite, and fine clastics.
			Salado		1,600±	Mainly halite and argillaceous halite. These rocks, thinner layers of sulphate minerals (chiefly anhydrite and polyhalite), and minor claystone, siltstone, and sandstone occur in cyclic sequences, 2-30 feet thick. Potash ore in irregularly lenticular to tabular bodies near middle. Generally 1,600-2,000 feet thick near Gnome site and southern potash mines; thins northward over buried Capitan Reef to 700-1,200 feet near northern mines. Thinner farther north.
			Castile		1,600+	Mainly anhydrite, generally interlaminated with calcite in central and lower parts of formation. Two intervals of fairly pure halite, generally 200-350 feet thick, persist throughout northern Delaware basin. Minor limestone. Thins abruptly shelfward within vicinity of mines and elsewhere at margins of basin; no more than a thin tongue crosses buried Capitan Reef. Thickness fairly uniform within basin.
	Guadalupian	Delaware Mountain	Bell Canyon		1,150±	Brown and gray sandstone and minor limestone and shale. Grade at edges of Delaware basin, including vicinity of potash mines, into reef of light-gray Capitan Limestone, as much as 2,000 feet thick. Behind the reef, dolomite, siltstone, sandstone, and anhydrite of upper Artesia Group is equivalent and similar in thickness to Bell Canyon.
			? Cherry Canyon		1,050±	Gray and brown sandstone, limestone, and minor shale. Near northern-most mines and elsewhere along margin of basin, it grades laterally into carbonate reef (Goat Seep Reef) or bank and then, behind the reef, into dolomite, anhydrite, and fine clastics of lower Artesia Group and upper San Andres Formation.
			? Brushy Canyon		1,600±	Gray sandstone and a little brown and black shale and brown limestone. Thins north of potash mines and gives way to mainly dolomite (lower San Andres Formation) on shelf to north. Laps out against ancient arch west of basin.
	Leonardian		Bone Spring		3,000±	Brown and dark-gray limestone and subordinate brown and gray shale and gray sandstone. North of the mines and elsewhere generally behind the younger Permian reefs, it grades laterally into carbonate reefs and banks (Abo Reef, Victorio Peak Limestone) and finally into dolomite and minor shale, siltstone, sandstone, and anhydrite (principally Yeso Formation).



	Leonardian	Bone Spring	3,000±	Brown and dark-gray limestone and subordinate brown and gray shale and gray sandstone. North of the mines and elsewhere generally behind the younger Permian reefs, it grades laterally into carbonate reefs and banks (Abo Reef, Victorio Peak Limestone) and finally into dolomite and minor shale, siltstone, sandstone, and anhydrite (principally Yeso Formation).
	Wolfcampian		1,750±	Similar to Bone Spring Formation. Brown and gray limestone and shale and gray sandstone. Much of limestone grades westward to dolomite beneath Guadalupe Mountains. Thins gradually northward in vicinity of Gnome site and potash mines.
				UNCONFORMITY
PENNSYLVANIAN			2,500±	Dark-gray shale and subordinate gray and brown limestone in central part of ancestral Delaware basin, near and south of Gnome site. To north and west, shale becomes subordinate to limestone, and lenses of sandstone are common, especially in lower part. To east, in Lea County, conglomerate and sandstone are common locally. Thickest (about 3,000 feet or more) in central Lea County and western Eddy County.
				UNCONFORMITY
MISSISSIPPIAN			1,100±	Upper sequence of gray, black, and brown shale, with some carbonates in northern and western parts of region. Lower sequence of gray and brown, commonly cherty limestone and basal dark-gray organic-rich shale. Limestone partially grades to shale southeast of Gnome site. System thickens to southeast and thins to west.
?				
ORDOVICIAN-SILURIAN-DEVONIAN			1,900±	Dolomite and limestone, commonly cherty. Subordinate shale and sandstone. Thin detrital unit common at base. Thickens to east and southeast.
				UNCONFORMITY
PRECAMBRIAN				Probably mainly granitic rocks. Local metasedimentary, metavolcanic, and volcanic rocks.

Modified by W. H. Hays from drawing by J. B. Cooper (1971, Fig. 5)

EXPLANATION

FIGURE II-36 continued --Generalized stratigraphic column at Gnome site and description of lateral variations.

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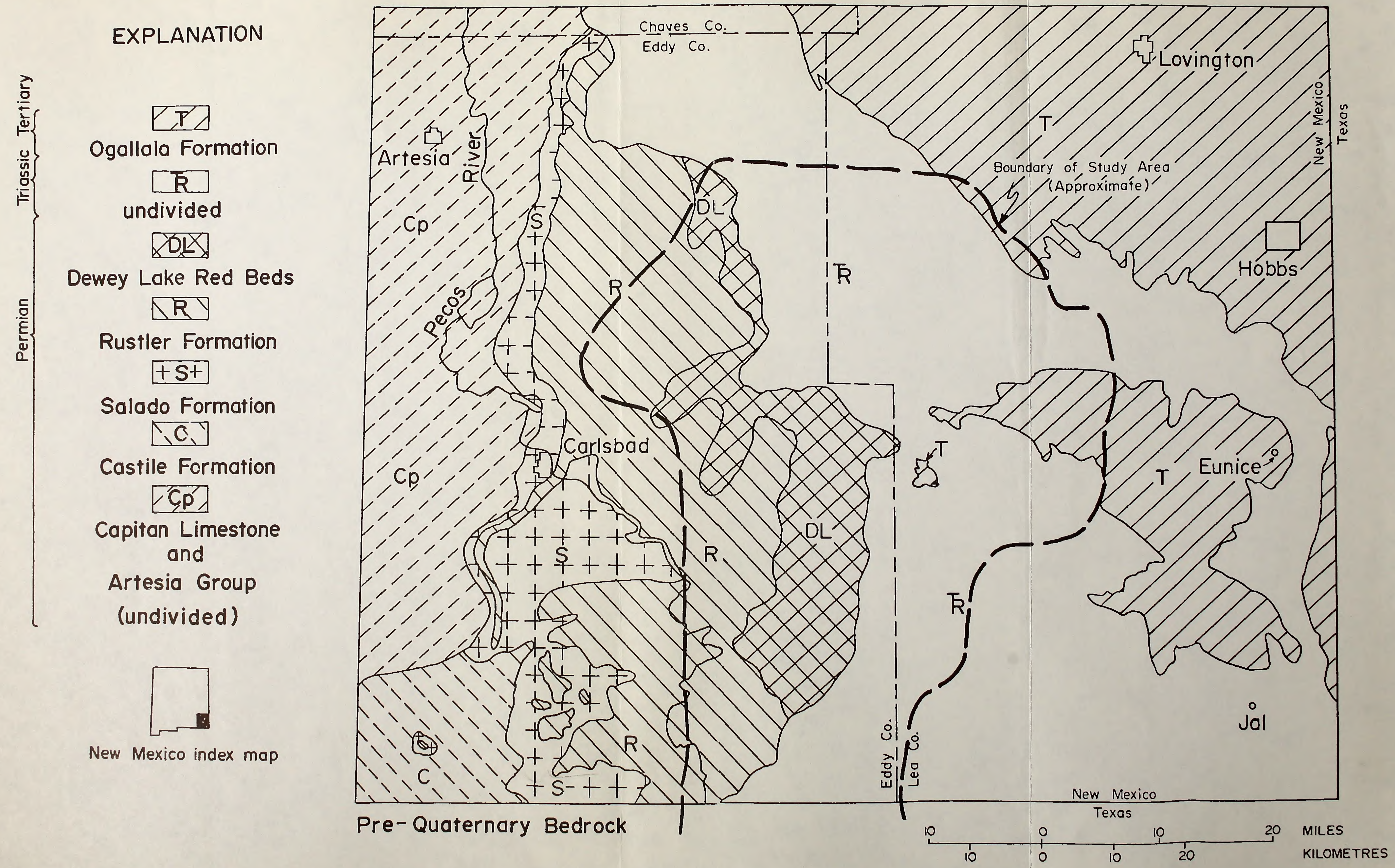
The pre-Ochoan Permian rocks of the Delaware Basin, however, change facies and have different names outside of the basin. While many hundreds of feet of the Ochoan Castile Formation evaporites accumulated in the basin, apparently little accumulated on the shelf and platform. After Castile deposition, the overlying Salado Formation, which contains the significant potash minerals, was deposited well over the Capitan Reef to the north and east. The relation between the rock units of the shelf, reef, and basin are shown in Figure II-37.

The contact between the Salado and the overlying Rustler Formation is usually gradational; however, in the Nash Draw area, a layer of solution breccia or residuum immediately above the salt makes the determination of the contact indefinite. This solution breccia consists of brecciated and collapsed layers of gypsum, separated by irregular seams and masses of reddish-brown and gray clay and silt. The breccia shows evidence of salt solution. The layer of solution breccia ranges in thickness from a few feet to as much as 150 feet (Jones, 1959, p. 13). This breccia is derived partly from rocks of the overlying Rustler Formation and partly from rocks of the Salado Formation.

Geologists are not in total agreement as to the position in the geologic section of this layer of breccia. Some Geologists place the top of the Salado Formation at the base of the Culebra Dolomite Member of the Rustler Formation, thus including the breccia and a few tens of feet of predominatly anhydrite and clastic beds in the Salado. Others place the contact at the top of the highest thick salt bed in the Salado Formation (this bed has an irregular surface that generally marks the change from weathered to unweathered rocks) and consider the breccia to be a part of the Rustler Formation. Moore (1958, p. 3) considers the breccia layer as part of the Salado and identifies it as the upper leached member of the Salado Formation. About 60 feet of this material is present at the Gnome Site. In this report, the top of the Salado Formation is considered to be the top of the highest thick salt bed and the solution breccia is considered to be a part of the Rustler Formation.

The upper surface of the Salado Formation, according to Jones (1954, p. 110) is conformably overlain by the Rustler Formation. King (1942, p. 762) and Adams (1944, p. 1608) state that the Salado in the Delaware Basin was truncated



MAPII-3 . - Simplified geologic map of southeastern New Mexico showing distribution of rocks of pre-Quaternary age.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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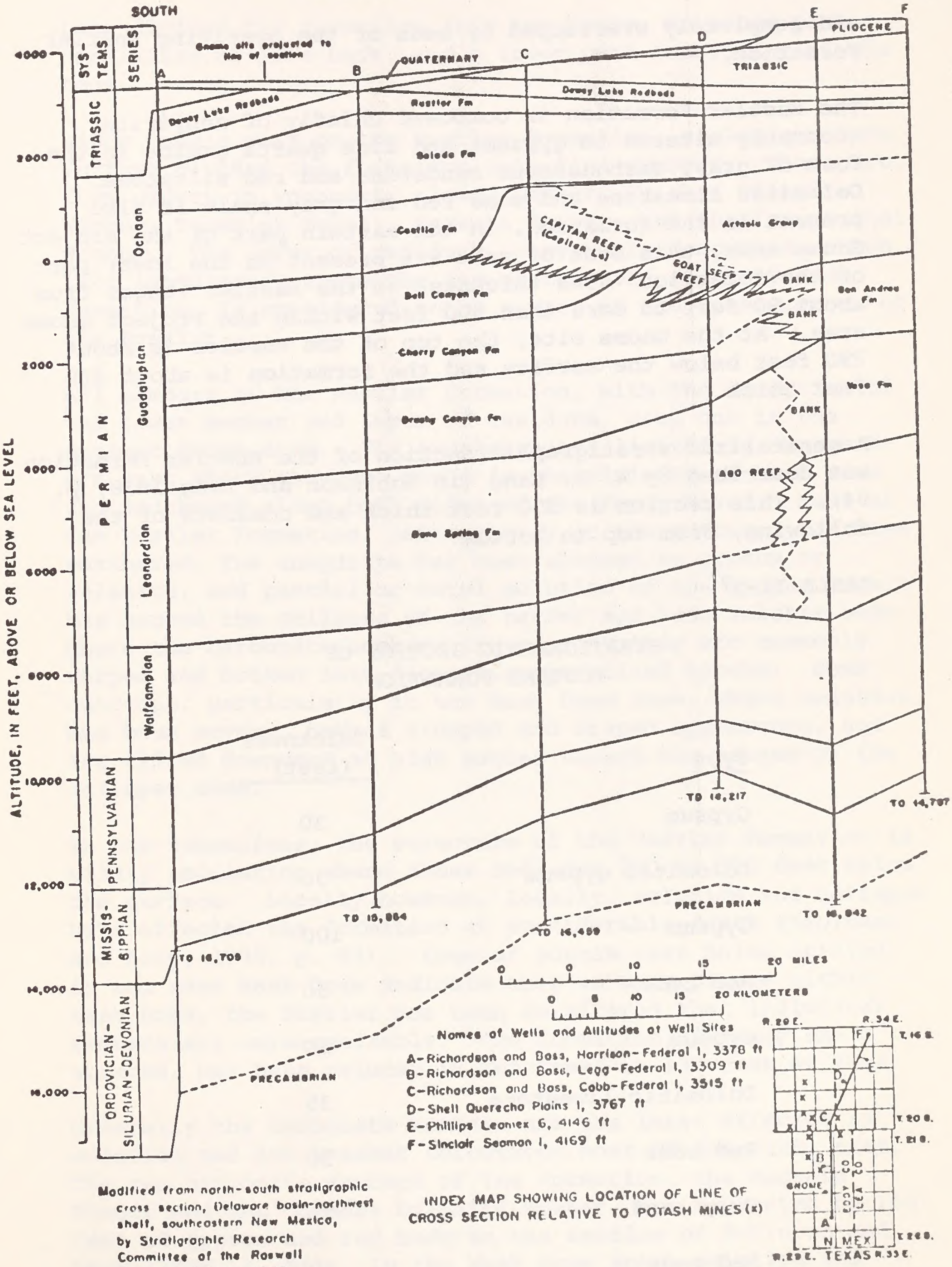


Names of Wells and Altitudes of Well Sites

A-Richardson and Bass, Harrison-Federal 1, 3378 ft
B-Richardson and Bass, Legg-Federal 1, 3309 ft
C-Richardson and Bass, Cobb-Federal 1, 3515 ft
D-Shell Querecho Plains 1, 3767 ft
E-Phillips Leonex 6, 4146 ft
F-Sinclair Seaman 1, 4169 ft

INDEX MAP SHOWING LOCATION OF LINE OF CROSS SECTION RELATIVE TO POTASH MINES (x)

Modified from north-south stratigraphic cross section, Delaware basin-northwest shelf, southeastern New Mexico, by Stratigraphic Research Committee of the Roswell Geological Society, 1958

Generalized geologic cross section from south to north through the vicinity of the Gnome site and the potash mines, Eddy and Lea Counties, New Mexico

FIGURE II-37

and completely overlapped by beds of the overlying Rustler Formation.

The Rustler Formation is composed chiefly of anhydrite (commonly altered to gypsum) and fine quartz grains in the form of gray, carbonaceous sandstone and red siltstone. Dolomitic limestone and some red and gray shale is also present in the formation. In the eastern part of the Project Gnome area, thin beds of salt are present in the lower part of the formation. The thickness of the Rustler ranges from about 90 feet to more than 500 feet within the Project Gnome area. At the Gnome site, the top of the Rustler is about 290 feet below the surface and the formation is about 420 feet thick.

A generalized stratigraphic section of the Rustler Formation was described by W. B. Lang (in Robinson and Lang 1938, p. 84). This section is 500 feet thick and consists of the following, from top to bottom:

TABLE II-57

STRATIGRAPHIC SECTION OF
RUSTLER FORMATION

Type	Thickness (feet)
Gypsum	30
Dolomitic gypsum	30
Gypsum	100
Red beds	30
Gypsum	20
Dolomitic limestone	35
Red beds	30
Gray sand	70
Red beds	20
Gypsum	130
Red beds	5

Lang divided the formation into two parts; an upper part consisting of five beds, and a lower part consisting of six beds.

Since Lang's work on the Rustler Formation, geologists have further divided the formation into five members. These are, from oldest to youngest: lower member; Culebra Dolomite Member; Tamarisk Member; Magenta Member; and the Forty-niner Member. The layer of residuum, previously described, which lies immediately above the top of the salt of the Salado Formation, is considered to be a part of the lower member of the Rustler.

All members of the Rustler Formation, with the exception of the lower member and layer of residuum, crop out in the Project Gnome area. The exposures are limited to the western part where they are found in the vicinity of Nash Draw and southward along both sides of the Pecos River. Most of the Rustler Formation, particularly in the outcrop, has been weathered. The anhydrite has been altered to gypsum or selenite, and partial or total solution of the gypsum layers has caused the collapse of the harder and less soluble beds. Where the carbonate members are present they are commonly warped and broken into discontinuous tilted blocks. Some outcrops, particularly in the Nash Draw area, where solution has been severe, have a slumped and draped appearance, and are tilted downward at high angles toward the center of the collapse area.

In the subsurface, the structure of the Rustler Formation is mildly undulating where these beds are 200 to 300 feet below the surface. Locally however, locally, solution and collapse have affected the formation at considerable depth (Robinson and Lang, 1938, p. 84). Logs of potash test holes drilled in and near Nash Draw indicate that in many places within Nash Draw, the Rustler has been so altered that individual members are unrecognizable. The formation, in many instances, has been reduced in thickness to 100 feet or less.

Generally the carbonate members are the least affected by solution and are present throughout most of the study area. The two carbonate members of the formation, the Magenta Member and the Culebra Dolomite Member, are separated by 150 feet of gypsum and red beds in the section of Robinson and Lang (1938, p. 84). In the Nash Draw area, solution and collapse has, in some localities, removed all the rock section between the two members, and the Magenta Member rests directly upon the Culebra Dolomite Member. Most of the gypsum section in the formation in Nash Draw has been removed or severely altered, and only a residuum of red, brown, or gray silt remains in many places. Farther east, in the area where the Rustler Formation is overlain by rocks of Permian age or Triassic age, less alteration of the members of the Rustler has occurred. At the Gnome site, even though the thickness is less than in Lang's section, all members of the formation are present. Here the two carbonate members are separated by about 117 feet of anhydrite, gypsum, and siltstone.

(3) Dewey Lake Redbeds

Originally the Rustler Formation was overlain in this area by a formation now called the Dewey Lake Redbeds, but otherwise known as the Pierce Canyon Redbeds, Pierce Canyon Formation and Dewey Lake Formation. At places, this formation has been eroded away and at other places its eroded surface is covered by surficial deposits of Quaternary age (Brokaw and others, 1972, fig. 4). These beds are exposed in the northern part of Nash Draw (Vine, 1963, plate 1). Cooper (op. cit.) contains the description of these and younger rocks.

The Dewey Lake Redbeds are composed of a series of fine sandy to earthy red beds and thin beds of sandstone, polka-dotted with green reduction spots, and generally, irregularly veined with thin secondary selenite fillings. The color and texture of the beds are nearly uniform (Lang, 1935, p. 264). The green reduction spots are a most distinguishing feature of the red beds and are generally noted on logs of drill holes. The reduction spots, however, are not diagnostic of this particular formation. Most red beds of this type contain similar spots. The spots are caused by reduction of iron around an enclosed fragment of organic material or some similar reducing agent.

The Dewey Lake Redbeds in the SW¼SW¼SW¼ Sec. 4, T. 24 S., R. 30 E. directly overly the gypsum of the Middle member,are of the Rustler. At the base of the red beds, USGS test hole #2 penetrated a 5-foot layer of unconsolidated rubble and gravel. This layer is composed mainly of rocks of the Rustler Formation and consists of angular to sub-angular pieces of dolomite similar to the Magenta Member, and slightly rounded pieces of gypsum. Individual pieces of the rubble range in size from fine gravel to cobbles 4 inches or more in diameter.

These redbeds crop out at a number of localities within the study area. Particularly good exposures are present in the northern part, about 15 or 16 miles north of the Gnome site. At the Gnome site, the Dewey Lake Redbeds were penetrated at a depth of about 80 feet and were about 210 feet thick.

(4) Triassic Formations

Overlying the Dewey Lake Redbeds, unconformably, in the eastern half of the study area, are sandstones and red beds of the Dockum Group of Late Triassic age. The oldest formation is the Santa Rosa Sandstone, which is a pink to gray, conglomeratic, very poorly sorted, cross-stratified sandstone, locally interbedded with dark reddish-brown claystone and red siltstone. The sandstone crops out in the northern part of the area in the steep cliffs on the northeast side of Nash Draw. It has been penetrated in drill holes east of its outcrop, where it is nearly 300 feet thick. It is not present at the Gnome site.

A thick series of red shale, siltstone, and sandstone is present in the eastern third of the study area, overlying the Santa Rosa Sandstone. These red beds are probably the Chinle Formation of the Dockum Group. They are not known to crop out in the study area. In the subsurface, they are more than 1,000 feet thick in the extreme eastern part of the area.

(5) Tertiary Formations

The Ogallala Formation of late Tertiary (Pliocene) age covers relatively small areas in the northeastern and southeastern parts of the study area in Lea County. The outcrops are westward extensions or remnants of the southern High Plains. The formation lies on an erosional surface of the underlying red beds of the Triassic. The Ogallala is composed of clay, silt, sand, and gravel, and in places it is partially cemented. The beds are not continuous within the formation, and often change composition in short lateral distance. Generally, a layer of sand and gravel is present at the base of the formation where it may occupy channels in the red beds of the Triassic Age. In its outcrop area, the Ogallala attains a maximum thickness of 300 feet.

(6) Quaternary Formations

Rocks of Quaternary age unconformably overlie older rocks. The Gatuna Formation of Pleistocene (?) age is the oldest known in the area. The Gatuna crops out at several localities and is present at the Gnome site from about 40 to 80 feet below the land surface. At other places, drill holes have penetrated as much as 200 feet of this formation. Outcrops are discontinuous and the extent of the formation in the subsurface has not been determined. The Gatuna is composed of poorly consolidated sand, silt, and clay. Locally beds of medium to coarsegrained sandstone and pebble conglomerate are present. The dominant color is reddish-orange, grading to pink gray, or yellow.

Sediments believed to be Tertiary or Quaternary in age are present also in the south-central part of the area where they have been deposited in a deep trough that was created by solution of the underlying evaporites (Maley and Huffington, 1953, p. 541). Sparse information is available on the age and character of these sediments. Drillers' logs record a sequence of sand, sandy shale, and blue shale, commonly overlain by a section of red shale. The total thickness of the sediments deposited in this trough is about 1,900 feet. Other formations of the Quaternary System present in the area are of recent age and consist of caliche, alluvium, playa lake deposits, and windblown sand.

Caliche forms calcareous zones in soil and near-surface deposits. It ranges in composition from dense to thinly-banded, and contains sand grains and rock fragments. Where it has long been exposed at the surface, it is commonly very hard and resistant; however, where it has remained covered, it may be soft and friable. The color is primarily white to gray, but may be stained brown or red.

In much of the Gnome Site area, caliche forms a cap over older formations of several ages in the topographically high and less eroded parts of the land surface. It is mostly covered with a layer of windblown sand. However, in many places where the sand and soil cover has been removed, caliche crops out. Caliche is present also within the windblown sand deposits of the area. USGS test hole #1 penetrated a thin zone of caliche at 8 feet and a 3-foot bed between 11 and 14 feet. Caliche zones 1 foot or less in thickness were penetrated at depths of about 4 feet and about 12 feet in USGS test hole #2. The beds of caliche are generally less than 10 feet in thickness, and the maximum thickness probably does not exceed a few tens of feet. At the Gnome Site, a layer of friable caliche is present from about 7 to 10 feet beneath the land surface.

Alluvium in the form of sand and silt, locally conglomeratic, is present on some gentle slopes and in valley bottoms of the study area. The most extensive deposits are on the west side of the Pecos River, north of Malaga. Scattered small patches occur along both sides of the river throughout its course in the area. The thickness is generally not great except in the vicinity of the river where the alluvium is as much as 300 feet thick.

The alluvium near and west of the river north of Malaga, yields fairly large quantities of water to wells in most places. Although the quality is not good, the water is used for irrigation and other purposes.

Relatively small playa lakes occur mainly in the Nash Draw vicinity. The playas consist of silt, sand, and gypsum sand deposited in shallow and intermittent lakes. Laguna Grande de la Sal is a shallow lake that occupies a part of a large playa formed in a depression in the southern end of Nash Draw. The lake has no surface outlet and contains a brine solution that has been concentrated by evaporation. It is reported that salt was harvested from the lake as early as 1875. On the lowest swales of this playa there is a thin black mud layer which is mantled by a heavy crust of salt, which is in some places as much as 2 feet thick (Robinson and Lang, 1938, p. 85).

The gypsum and other materials deposited in the playas of Nash Draw often contain water. Wells finished in these sediments generally yield highly mineralized water that usually can be tolerated by stock, but is not suitable for domestic purposes.

Windblown sand deposits are common in the area east of the Pecos River. They overlie nearly all the land surface except where they have been removed by the wind. Generally, the sands are but a few feet thick, but where they have been concentrated by the wind conspicuous dunes have been formed. In the vicinity of the Gnome Site, numerous large dunes are present. The greatest concentration of conspicuous dunes in the area is about 5 miles northeast of the Gnome Site, where several square miles of the surface are covered by them. At the Gnome Site about 40 feet of sand, with some

caliche, overlies rocks of the Gatuna Formation. The wind-blown sands in this area are continuous with those that cover most of the land surface between the Pecos River and the High Plains, and which extend many tens of miles northward from the State line. These sands were called Mescalero sands by Darton (1928, p. 59).

d. Mineral Resources

(1) Potash Resources

Deposits of potassium-bearing minerals occur in a number of the rock formations of southeastern New Mexico. These minerals have been reported in the Yates, Tansill, Salado, and Rustler Formations (See Map II-4 in back pocket of this report.) However, the potassium-bearing minerals of commerical importance are restricted to the Salado Formation (See Map II-4 in back pocket of this report.) Within the Salado Formation, 12 bedded deposits or ore zones exist (numbered in order from bottom to top). The deposits are irregular in form and not all are present throughout a given vertical section. With the exception of the uppermost 12th ore zone, which occurs about 75 feet below the top of the Salado Formation, the remaining zones are confined to a stratigraphic interval of about 270 feet and occur in the middle part of the formation. The mineral of most common occurrence is polyhalite, which is not used presently as a source of potash because of its limited solubility and greater hardness when compared to the ore minerals. Potassium-bearing minerals are distributed laterally in the rocks from the Texas line northward about 100 miles to the north line of Lea County, and in places these minerals extend over 50 miles in an east-west direction. The commercial deposits are compartively restricted to an area of about 530 square miles along the east edge of Eddy County and west edge of Lea County. The measured potash reserves of southeastern New Mexico, and the known potash leasing areas are contained within this 530 square mile area. (See Map II-1 in back pocket of this report.) Within this area potash resources owned by the United States can be acquired only by competitive lease procedures.

Of the 12 ore zones, 6 have been mined for potash ores. Only sylvite and langbeinite are utilized from the ore zones because of their accumulation in economic quantity, their high K_2O content, their adaptability to current refining practice, and because of the demand for the fertilizer products that are produced. The lowermost or first ore zone has yielded the greatest amount of potash. Mineralization in the zone is principally sylvite. The geologic structure in the Delaware basin and surrounding area has an important bearing on the economics of potash exploration and mining. Because of a low southeastward regional dip, the salt beds containing potash-bearing zones occur at greater depth to the east and south. Thus, the first ore zone is mined on the west, while to the east, the 10th ore zone is mined, the 10th ore zone occurs several hundred feet above the 1st ore zone. The attitude of the ore zones are nearly flat to gently rolling. However, in some places, steep dips are present on the flanks of small warps in the rocks.

The location, distribution, and status of availability with respect to ongoing operations of the potash resources in the Carlsbad mining district are shown on Map II-4 in back pocket of this report. Areas of solid shading show areas of mining within which volumes of ore have been and are being removed from 1 or more ore zones. In these areas there may or may not be overlying or underlying ore zones which contain ores (economic resources) of potash. It is from these shaded areas that all past potash production has come and from which some ore will be taken in the future as remaining ore pillars are recovered in the last stages of mining. , Only minimal shaft pillars around shafts will remain. These areas are partially mined out and for the most part there are only remnant resources in mined ore zones.

Crosshatched areas on Map II-4 show the known limits and distribution of economic potash resources (ores) in the Carlsbad Mining District. It is from these ores that most of the domestic potash production must be gained in the future and upon which the U. S. must depend until methods exist by which the now subeconomic resources can be utilized. Potash ores in both the shaded and crosshatched areas are in beds 4 feet or more thick, containing either 10 percent K_2O as the mineral sylvite, 4 percent K_2O as the mineral langbeinite, or both minerals (mixed ores) in such proportions that the minimum K_2O requirement is satisfied.

Lined areas (diagonal lines) on Map II-4 show the areas of subeconomic potash resources in one or more ore zones or in beds not correlative with ore zones. Subeconomic resources are in beds less than 4 feet thick and/or contain less than 10 percent K_2O as the mineral sylvite, less than 4 percent K_2O as the mineral langbeinite, or both minerals in proportions not satisfying the minimum K_2O requirement. It is from these ores that much of the U. S. potash reserve and supply is expected to be developed in the distant future. Future use of this now subeconomic resource must await technological, economic, and perhaps political changes not now defined. In any event, most domestic potash available for extraction must be taken from the area of economic resources shown on Map II-4.

Potash production from southeastern New Mexico is of national importance. Table II-58 is a summary of United States production, sales, consumption, and value of potassium salts since 1930, the time during which potassium salts were recovered from the Carlsbad area. Based on production, sales, and consumption of potassium salts, the apparent self-sufficiency of the United States with respect to potash can be easily obtained by subtraction and can be expressed as a ratio (percent). As Table II-58 shows, the U. S. produced only about 24 percent of the potash apparently consumed in 1931. Domestic production gradually increased and sometime and in 1941 the Nation became self-sufficient in use and production of the first time in history.

Apparent self-sufficiency continued until about 1964, when the apparent consumption (demand) became greater than domestic supply. By 1974, the last year of record, the apparent consumption had greatly outstripped supply and U. S. production comprised only about 42 percent of apparent consumption. Thus, the domestic supply situation with respect to potash demand, has deteriorated steadily in the last decade. The shortfall in potash supply is met by foreign imports and consumption of potash in inventory from previous years.

The importance of New Mexico to the National potash requirement can be appreciated by comparing production of marketable potassium salts in Table II-58 to the marketable potassium salts produced in New Mexico shown in Table II-59. It can be seen that the bulk of domestic production has been obtained from New Mexico for many years. The percent by gross weight of domestic production of potash from New Mexico

TABLE II-58

Summary of United States production, sales, consumption
and value of potassium salts since 1930
(Short tons, dollars, and percent)

Year (1)	Production of marketable potassium salts		Sales of potassium salts by producers		Apparent consumption of potassium salts[1]		Apparent National self-sufficiency of potash[2] (percent) (8)
	Gross weight (2)	Approximate K_2O equivalent (3)	Gross weight (4)	Value at plant (5)	Gross weight (6)	Approximate K_2O equivalent (7)	
1931	133,920	63,880	133,430	3,086,955	678,165	262,000	24.4
1932	143,120	61,990	121,390	2,102,590	449,433	167,665	37.0
1933	333,110	143,378	325,481	5,296,793	775,549	293,000	48.9
1934	275,732	144,342	224,875	2,813,218	680,933	275,000	52.5
1935	357,974	192,793	406,922	4,993,481	930,000	420,000	45.9
1936	431,470	247,340	396,690	6,969,190	826,511	396,466	62.4
1937	486,090	284,497	466,933	9,019,534	1,000,853[3]	476,979[3]	59.6
1938	534,945	316,951	498,189	9,748,290	958,232[3]	467,542[3]	67.8
1939	546,757	312,201	634,014	12,028,195	[4]	387,424[4]	80.6
1940	658,249	379,679	677,892	12,562,050	859,689	448,912	84.6
1941	986,458	524,875	994,843	17,368,237	952,265	490,291	107.1
1942	1,267,455	679,206	1,277,317	22,962,518	1,200,937	628,049	108.2
1943	1,428,840	739,141	1,401,271	26,183,073	1,315,025	679,253	110.7
1944	1,578,498	834,568	1,543,420	29,487,413	[4]	753,893	110.7
1945	1,588,305	874,243	1,597,160	30,313,919	[4]	808,809	108.1
1946	1,687,735	931,812	1,673,249	32,175,716	[4]	867,197	107.5
1947	1,905,766	1,029,875	1,953,307	34,716,051	1,879,441	1,011,142	101.9
1948	2,138,493	1,139,881	2,148,807	35,998,758	2,073,629	1,100,787	103.6
1949	2,056,609	1,118,395	2,062,789	35,105,799	1,979,754	1,070,312	104.5
1950	2,241,044	1,286,762	2,220,803	39,695,038	2,483,320	1,409,940	91.3
1951	2,474,870	1,420,323	2,451,913	44,788,880	2,902,023	1,653,188	85.9
1952	2,866,462	1,665,113	2,757,252	59,852,000	3,013,489	1,730,514	96.2
1953	3,266,429	1,911,891	2,965,986	65,403,000	3,128,335	1,816,085	105.3
1954	3,322,395	1,948,721	3,270,006	71,819,000	3,377,850	1,970,901	98.9
1955	3,505,505	2,064,808	3,400,835	76,551,000	3,500,921	2,050,404	100.7
1956[5]	3,679,000	2,172,000	3,572,000	79,768,000	3,508,000	2,058,000	105.5

TABLE II-58
continued

Summary of United States production, sales, consumption
and value of potassium salts since 1930 continued
(Short tons, dollars, and percent)

Year (1)	Production of marketable potassium salts		Sales of potassium salts by producers		Apparent consumption of potassium salts[1/]		Apparent National self-sufficiency of potash[2/] (percent) (8)
	Gross weight (2)	Approximate K_2O equivalent (3)	Gross weight (4)	Value at plant (5)	Gross weight (6)	Approximate K_2O equivalent (7)	
1957	3,840,000	2,266,000	3,625,000	79,628,000	3,497,000	2,085,000	108.7
1958	3,640,000	2,147,000	3,954,000	81,577,000	3,813,000	2,281,000	94.1
1959	4,033,000	2,383,000	4,191,000	83,903,000	4,051,000	2,373,000	100.4
1960	4,472,000	2,638,000	4,412,000	85,470,000	3,997,000	2,337,000	112.9
1961	4,629,000	2,732,000	4,226,000	95,388,000	3,888,000	2,276,000	120.0
1962	4,167,000	2,452,000	4,615,000	105,608,000	4,373,000	2,557,000	95.9
1963	4,871,000	2,864,000	4,587,000	103,828,000	4,906,000	2,878,000	99.5
1964	4,954,000	2,897,000	5,201,000	120,284,000	5,407,000	3,164,000	91.6
1965	5,401,000	3,140,000	5,027,000	121,161,000	5,795,000	3,391,000	92.6
1966	5,701,000	3,320,000	5,377,000	116,340,000	6,868,000	4,003,000	82.9
1967	5,649,000	3,299,000	5,363,000	100,566,000	7,117,000	4,141,000	79.7
1968	4,769,000	2,722,000	5,094,000	81,620,000	7,413,000	4,337,000	62.8
1969	4,918,000	2,804,000	5,340,000	78,062,000	8,059,000	4,700,000	59.7
1970	4,853,000	2,729,000	4,703,000	92,373,000	8,074,000	4,709,000	58.0
1971	4,543,000	2,587,000	4,578,000	102,099,000	8,217,000	4,794,000	54.0
1972	4,738,000	2,659,000	4,653,000	104,680,000	8,279,000	4,815,000	55.2
1973	4,684,000	2,603,000	5,174,000	123,738,000	9,641,000	5,563,000	46.8
1974	4,716,000	2,552,000	4,707,000	158,354,000	10,537,000	6,084,000	42.0

Source: U.S. Bureau of Mines and U.S. Geological Survey

1/ Measured by sold or used plus imports minus exports.

2/ Measured by K_2O equivalent of marketable potassium salts divided by K_2O equivalent of apparent consumption of potassium salts and expressed as percent.

3/ Actual sales for apparent consumption.

4/ Apparent annual consumption of short tons of potassium salts not readily available.

5/ Information expressed to the nearest 1000 short tons or 1000 dollars in this and succeeding years.

TABLE II-59 Crude potassium salts produced, and marketable salts produced and sold or used by the New Mexico potash industry since 1930
(Short tons and dollars)

Year (1)	Crude Salts[1] (Mine production gross weight) (2)	Marketable potassium salts					Cumulative Value (8)
		Production		Sold or used			
		Gross weight (3)	Approximate K_2O equivalent (4)	Gross weight (5)	Approximate K_2O equivalent (6)	Value (7)	
1931	57,057			40,756	10,738		
1932	88,105	10,072	6,245	56,672	18,609		
1933	328,802	57,441	35,014	222,690	77,978		
1934	300,239	58,514	35,108	120,719	55,621	22,167,682[2]	
1935	456,722	140,509	88,418	219,926	116,169		
1936	582,302	208,842	126,985	213,712	118,546		
1937	739,914	262,576	164,741	287,329	165,079		
1938	896,828	314,755	192,233	296,562	170,168		22,167,682
1939	870,513	303,249	182,743	387,340	217,913	7,070,751	29,238,433
1940	1,206,427	425,977	248,351	457,859	262,716	8,567,894	37,806,327
1941	2,265,972	670,891	388,995	817,295	423,977	14,078,375	51,884,702
1942	3,035,549	861,475	491,435	1,048,175	539,235	17,218,065	69,102,767
1943	3,433,243	1,203,126	609,638	1,178,570	604,414	21,918,503	91,021,270
1944	3,749,250	1,337,459	694,872	1,304,497	679,721	24,739,507	115,760,777
1945	3,949,983	1,354,187	738,782	1,360,189	733,176	25,456,731	141,217,508
1946	4,309,649	1,428,860	782,166	1,429,780[3]	789,473	27,187,228	168,404,736
1947	4,655,732	1,625,870	866,070	1,659,266	880,605	28,035,675	196,440,411
1948	5,108,372	1,841,054	964,940	1,850,976	967,945	29,177,328	225,617,739
1949	4,852,903	1,733,739	927,621	1,744,427	932,497	27,950,111	253,567,850
1950	5,802,004	1,904,565	1,086,996	1,878,094	1,072,772	33,608,000	287,176,000
1951	6,615,891	2,138,439	1,223,139	2,216,391	1,217,617	43,428,000	330,604,000
1952	7,852,732	2,530,596	1,468,029	2,439,042	1,411,125	52,483,000	383,087,000
1953	9,100,671	2,937,960	1,721,435	2,661,587	1,552,831	58,076,000	441,163,000
1954	9,975,460	3,007,724	1,763,378	2,954,043	1,732,240	64,367,000	505,530,000
1955	10,956,466	3,196,799	1,883,766	3,097,771	1,826,118	69,058,000	574,588,000
1956[4]	11,941,000	3,384,000	1,997,000	3,279,000	1,931,000	72,802,000	647,390,000

TABLE II-59 continued

Crude potassium salts produced, and marketable salts produced and sold or used by the New Mexico potash industry since 1930 - continued
(Short tons and dollars)

Year (1)	Crude Salts1/ (Mine production gross weight) (2)	Marketable potassium salts					Cumulative Value (8)
		Production		Sold or used			
		Gross weight (3)	Approximate K_2O equivalent (4)	Gross weight (5)	Approximate K_2O equivalent (6)	Value (7)	
1957	12,893,000	3,528,000	2,080,000	3,353,000	1,977,000	73,243,000	720,633,000
1958	12,224,000	3,355,000	1,978,000	3,650,000	2,157,000	75,343,000	795,976,000
1959	13,933,000	3,707,000	2,189,000	3,821,000	2,258,000	76,725,000	872,701,000
1960	15,071,000	4,138,000	2,440,000	4,092,000	2,412,000	78,707,000	941,408,000
1961	15,653,000	4,281,000	2,523,000	3,882,000	2,281,000	87,415,000	1,038,823,000
1962	14,115,000	3,758,000	2,208,000	4,206,000	2,476,000	95,851,000	1,134,674,000
1963	16,414,000	4,504,000	2,643,000	4,213,000	2,484,000	94,925,000	1,229,599,000
1964	17,356,000	4,585,000	2,675,000	4,815,000	2,814,000	110,772,000	1,340,371,000
1965	18,557,000	4,919,000	2,848,000	4,607,000	2,677,000	110,424,000	1,450,795,000
1966	20,105,000	5,096,000	2,953,000	4,872,000	2,827,000	104,668,000	1,555,463,000
1967	18,906,000	4,950,000	2,883,000	4,797,000	2,784,000	88,788,000	1,644,251,000
1968	14,382,000	4,051,000	2,289,000	4,425,000	2,511,000	70,198,000	1,714,449,000
1969	15,519,000	4,131,000	2,327,000	4,433,000	2,521,000	64,863,000	1,779,312,000
1970	16,246,000	4,286,000	2,390,000	3,966,000	2,227,000	78,299,000	1,857,611,000
1971	16,117,000	4,030,000	2,291,000	4,101,000	2,317,000	89,325,000	1,946,936,000
1972	17,285,000	4,122,000	2,296,000	4,089,000	2,285,000	89,861,000	2,036,797,000
1973	17,092,000	3,938,000	2,168,000	4,414,000	2,422,000	103,038,000	2,139,835,000
1974	17,206,000	3,949,000	2,102,000	3,885,000	2,061,000	126,023,000	2,265,858,000

Source: U. S. Bureau of Mines and U. S. Geological Survey

1/ Sylvite and langbeinite ores.
2/ Total value for the years 1931 through 1938
3/ Estimated
4/ Information expressed to the nearest 1,000 short tons or 1,000 dollars in this and succeeding years.

by years can be obtained by dividing column 3 of Table II-59 by column 1 of Table II-59. Table II-59 also shows annual value and cumulative value of marketable potassium salts sold or used since 1930. The cumulative value (column 8) has surpassed two billion dollars in the 44 year period of record. Thus, the Carlsbad mining district can significantly be included among the few multi-billion dollar mining districts in the world.

Table II-60 shows that the grade of ore mined has decreased from over 26 percent K_2O in 1933 to less than 16 percent in 1974. Similarly, the ratio of ore mined to marketable potassium salts has steadily increased from less than 2 to 1 in early years to over 4 to 1 in 1972. The estimated gross weight of waste generated by mining and milling operations is in excess of 283 million short tons, estimated to be equivalent to a gross volume of about 262 million cubic yards. This amount is the total waste, regardless of distribution, including solid waste in salt piles and tailings ponds, waste in solution in brines, and waste entrained in dust, aerosols, and clouds.

Subsidence effects at land surface occur during and after underground mining, wherever the degree of pillar extraction is sufficient to remove critical support from the overlying rock mass. Subsidence effects take place over areas larger than the mined area because induced strains (deformation) occur at a limiting angle drawn from the underground working to land surface. In the Carlsbad mining district, the configuration as a result of the limit angle, is about the same distance laterally as the depth of the deposit, or at a limiting angle of about 45 degrees. Thus, the subsidence effects of downward ground movement and horizontal strain at land surface will not extend much beyond 1000 feet laterally from the area of removal of pillar support in an ore deposit about 1000 feet below land surface. If the ore deposit is deeper, the surface movements will extend further. Maximum land subsidence and ground movement occurs over the areas of most complete ore extraction, becoming inconsequential at the extremity of the area defined by projection of the limiting angle. Experience in the mining district has shown that maximum land subsidence can be expected to be about 2/3 of the height of the ore zone mined in subsurface. Ore zones now being mined range from 4 to 8 feet thick. Thus a maximum subsidence of 2-2/3 to 5-1/3 feet can be expected. Subsidence at land surface has not had serious effects because the area is sparsely populated, structures are few, TABLE II- 60 Calculated average ore grade, ratio of ore produced per ton of potassium salts produced, and estimated gross weight and gross volume of waste generated by the New Mexico potash industry since 1930

Year (1)	Calculated average ore grade[1/] (percent) (2)	Ore produced per ton of marketable potassium salts produced (short tons) (3)	Estimated gross weight of waste produced (short tons) (4)	Estimated gross volume of waste produced[2/] (cubic yards) (5)
1931	25.49	1.40[3/]	16,301[4/]	15,094
1932	24.59	1.56[3/]	31,433[4/]	29,105
1933	26.20	1.48[3/]	106,112[4/]	98,252
1934	24.55	2.49[3/]	179,520[4/]	166,222
1935	24.38	2.08[3/]	236,796[4/]	219,256
1936	24.66	2.73[3/]	368,590[4/]	341,287
1937	25.10	2.58[3/]	452,585[4/]	419,060
1938	23.85	2.85[5/]	582,073	538,957
1939	24.39	2.25[3/]	483,173[4/]	447,382
1940	24.19	2.64[3/]	748,568[4/]	693,119
1941	22.13	2.77[3/]	1,448,677[4/]	1,341,368
1942	21.52	2.89[3/]	1,976,749[4/]	1,830,323
1943	21.19	2.85	2,230,117	2,064,923
1944	21.33	2.80	2,411,791	2,233,140
1945	21.34	2.91	2,595,796	2,403,515
1946	20.72	3.02	2,880,789	2,667,397
1947	20.74	2.86	3,029,859	2,805,425
1948	20.94	2.77	3,267,318	3,025,294
1949	21.00	2.79	3,119,164	2,888,115
1950	20.65	3.04	3,897,439	3,608,740
1951	20.39	3.09	4,477,452	4,145,789
1952	20.94	3.10	5,322,136	4,927,904
1953	21.0	3.10	6,162,711	5,706,214
1954	19.91	3.32	6,967,736	6,451,607
1955	19.71	3.43	7,759,667	7,184,877

TABLE II-60 continued

Calculated average ore grade, ratio of ore produced per ton of potassium salts produced, and estimated gross weight and gross volume of waste generated by the New Mexico potash industry since 1930 continued

Year (1)	Calculated average ore grade 1/ (percent) (2)	Ore produced per ton of marketable potassium salts produced (short tons) (3)	Estimated gross weight of waste produced (short tons) (4)	Estimated gross volume of waste produced 2/ (cubic yards) (5)
1956	19.30	3.53	8,557,000	7,923,000
1957	18.85	3.65	9,365,000	8,671,000
1958	18.86	3.64	8,869,000	8,212,000
1959	18.58	3.76	10,226,000	9,469,000
1960	18.85	3.64	10,933,000	10,123,000
1961	18.80	3.66	11,372,000	10,530,000
1962	18.55	3.76	10,357,000	9,590,000
1963	18.78	3.64	11,910,000	11,028,000
1964	17.99	3.79	12,771,000	11,825,000
1965	18.12	3.77	13,638,000	12,628,000
1966	17.55	3.95	15,009,000	13,897,000
1967	18.16	3.82	13,956,000	12,922,000
1968	17.83	3.55	10,331,000	9,566,000
1969	18.44	3.76	11,388,000	10,544,000
1970	18.07	3.79	11,969,000	11,074,000
1971	17.32	4.00	12,087,000	11,192,000
1972	16.61	4.19	13,163,000	12,188,000
1973	16.07	4.34	13,154,000	12,180,000
1974	15.50	4.36	13,257,000	12,275,000
Total			283,055,552	262,089,365

Calculated from U.S. Bureau of Mines and U.S. Geological Survey data.

1/Percent K2O equivalent

2/Density assumed equal to 80 pounds per cubic foot after milling;includes all material produced without regard to state or mode of entrainment.

3/In early years crude salts were exported for fertilizer and waste did not accrue from these salts as a result of processing. Thus, this number is derived as gross weight of crude ore divided by gross weight of potassium salts sold or used.

4/Gross weight of crude ore mined minus total products sold or used;otherwise minus gross weight of marketable potassium salts produced. The gross weight of potassium salts sold or used could not accrue as waste product.

5/This year (1938) is the first that the gross weight of merchantable potassium salts produced exceeded total potassium salts sold or used.

and existing structures are protected by pillars, within which only limited ore extraction is permitted, thus keeping strains within allowable limits.

Linear structures such as roads and powerlines are more difficult to insulate completely from subsidence effects, but can be designed for the subsidence area. For example, extra wire is incorporated into the length of powerlines and telephone lines, permitting the lines to respond to ground strains without harmful change.

Maximum areas within which subsidence effects have occurred and will occur are shown on Map II-5 in back pocket of this report. Areas shown include places where strains are inconsequential even though likely detectable. Areas within which some subsidence effects have occurred total about 14 square miles and areas within which subsidence effects will occur in the future total about 40 square miles.

Total potash reserves in the Carlsbad mining district have been variously estimated from time to time. Recent estimates generally differ from those made previously because the ore grades utilized decline with time, and the total measured reserves vary with information available and definitions used by the estimating author or group. A meaningful estimate was compiled in 1965 by Alto and others (1965, pp. 308-309) in which the total potash reserve was estimated to be about 1.3 billion tons with an average grade of 17 percent K_2O as sylvite and 0.2 billion tons with an average grade of 9 percent K_2O as langbeinite (1.5 billion tons with an average grade of 16% K_2O). These reserves occurred in beds not less than 4 feet thick. The U. S. Geological Survey is presently conducting investigations of the potash ore reserves within the mining district.

A preliminary unrefined estimate of ore reserves in beds not less than 4 feet thick, containing 10 percent K_2O as sylvite, 4 percent K_2O as langbeinite, or an equivalent combination of sylvite and langbeinite (mixed ores), indicates that as much as 3.6 billion tons of potash ores exist within the Carlsbad mining district.

By the end of 1964, a reported 220,790,786, short tons of ore had been extracted. Assuming 85 percent ore recovery, about 259,753,865 tons of potash ore had been mined or lost in mining.

After 1964, ore recoveries were probably about 90 percent, which indicates that an additional 190,461,134 short tons of ore were mined or lost in mining as of January 1, 1975.

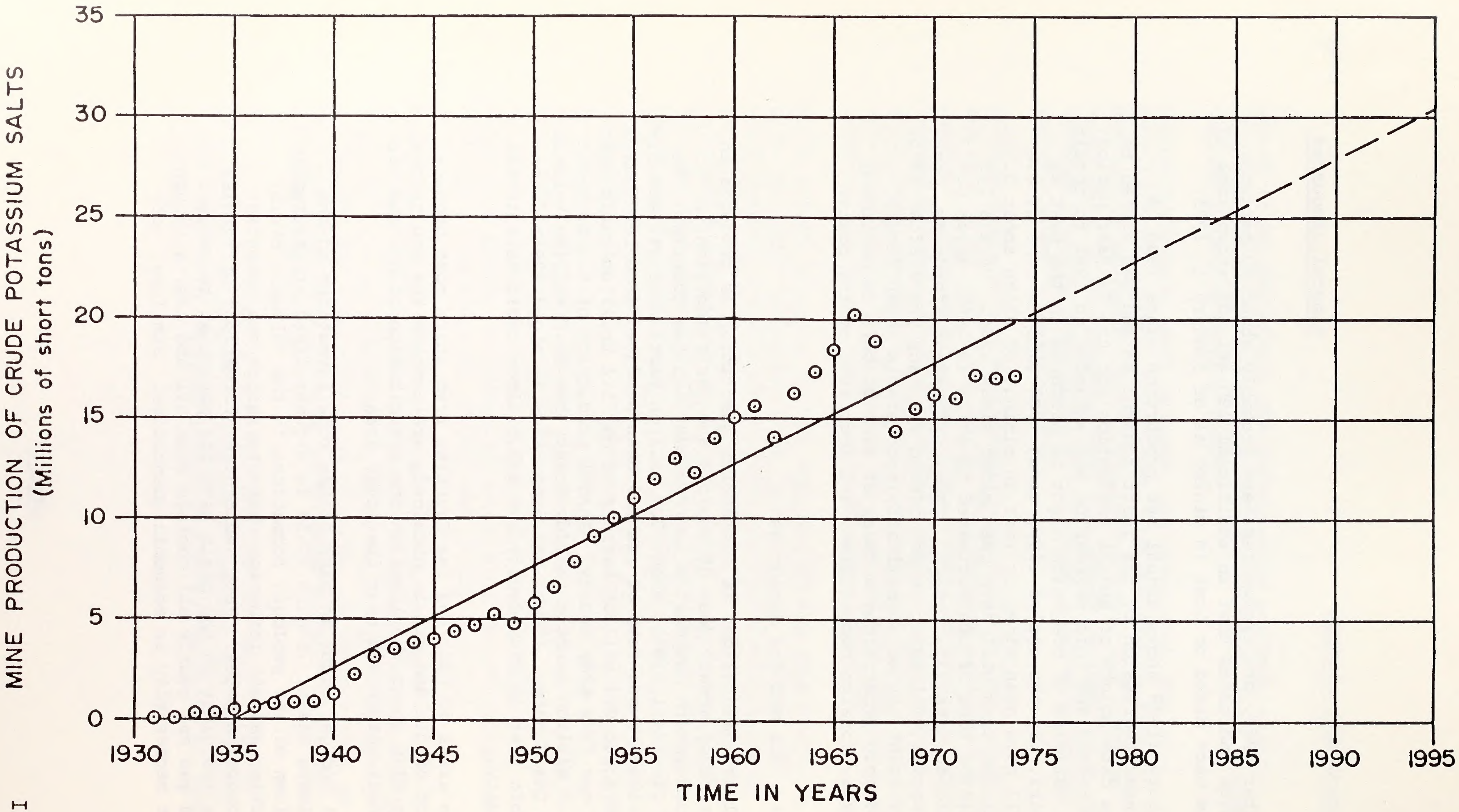
Figure II-38 shows annual ore production since 1930. A linear regression by the least squares method was fitted to the data points of annual production for the 44 year period of record and this regression was extended to 1995 to obtain an estimate of ore which might be produced in the next 20 years. By the end of 1995, about 1.04 billion tons of ore will have been mined or lost in mining, of which about 0.783 billion tons will have been mined since 1964. Of the 1.5 billion tons of ore estimated to exist in 1965, about 0.717 billion tons will remain. Thus, by present standards, ore reserves will exist in the ground for many years after 1995, but might not be economically recoverable under future economic constraints because of such factors as declining grade, foreign competition, and increased mining costs.

(2) Oil and Gas Resources

Oil and natural gas in commercial quantities is produced in the study area. Most of the oil and gas production in southeastern New Mexico is from Eddy and Lea Counties. As of January 1, 1975, about 2.4 billion barrels of oil and 3.8 trillion cubic feet of gas had been produced from Lea County and about 0.4 billion barrels of oil 1.2 trillion cubic feet of gas from Eddy County. Annual production of oil is about 21.5 million barrels in Eddy County and 66.0 million barrels in Lea County. Annual gas production is about 229 billion cubic feet in Eddy County and 437 billion cubic feet in Lea County.

The areas in Eddy and Lea Counties from which most production of oil and gas is obtained, are outside the study area. Map II-6 shows the location and distribution of oil and gas fields within and near the study area.

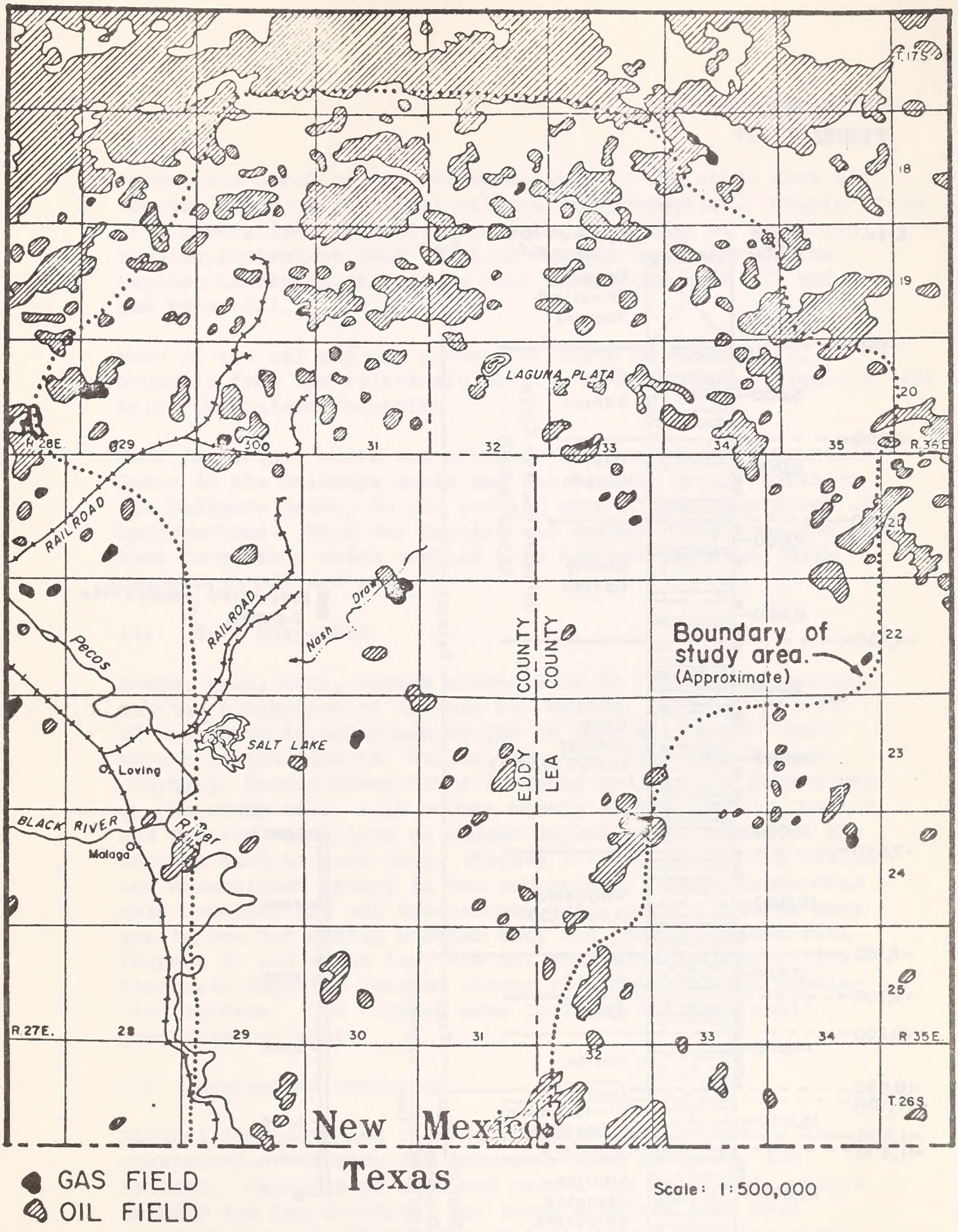
Oil and gas occur in many of the rock formations in the Delware Basin. Figure II-39 is a generalized stratigraphic column of the geologic formations in the Delaware Basin, showing salient formation characteristics and potential production zones. Many sedimentary formations of Permian age and older in the basin have the potential to produce oil and gas and nearly all contain some oil and gas, although not necessarily in economic quantities. Similary, rock



⊙ Production of crude potassium salts, by year, for the 1931-1974 period of record.

——— — — Regression line (least squares method) for 44 paired values of production vs/ time, solid for the period of record, dashed where extended to 1995.

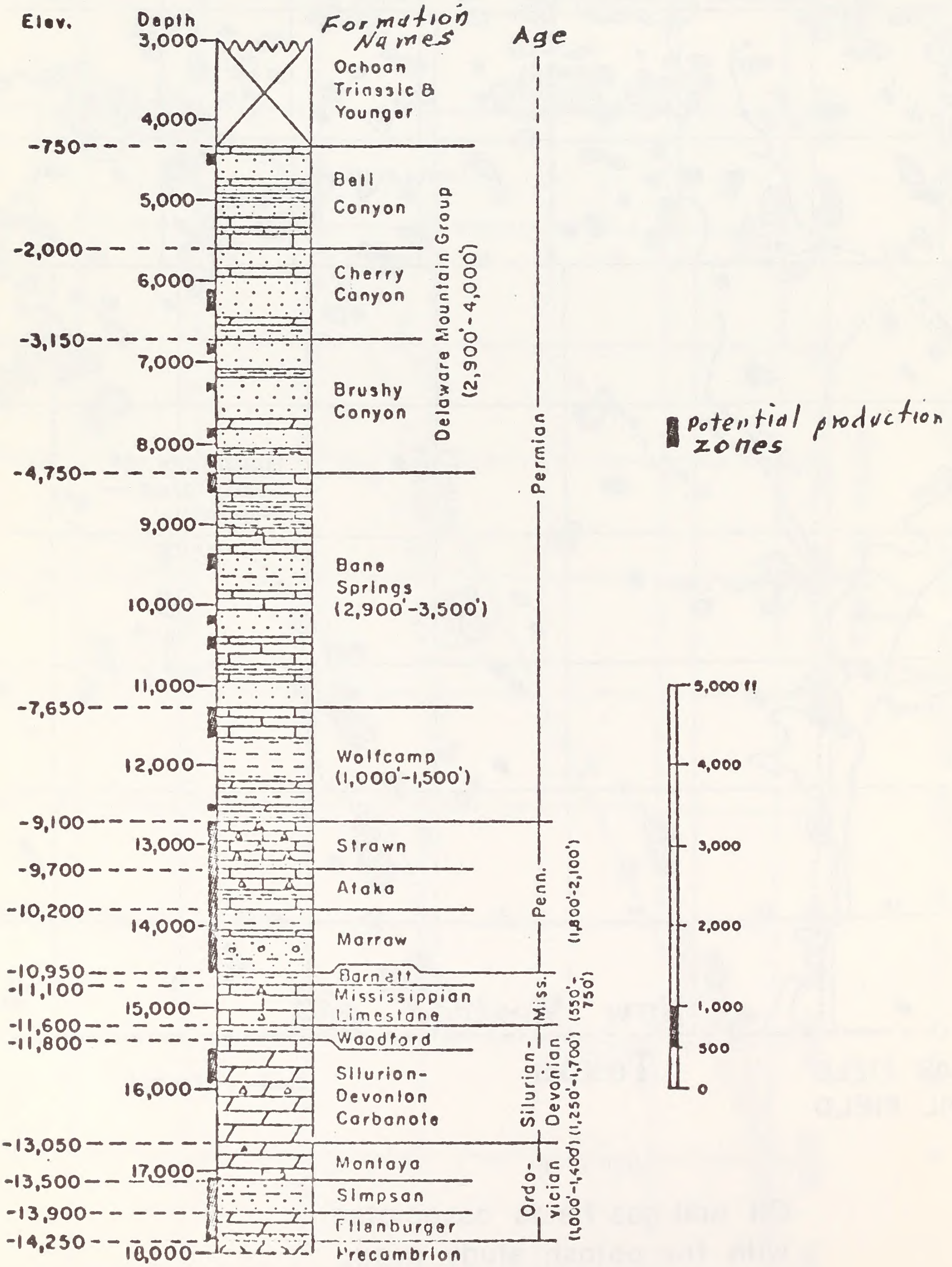
FIGURE II-38



MAP II-6

Oil and gas fields associated with the potash study area, Southeastern New Mexico.

FIGURE II-39



Generalized stratigraphic column of rocks in the Delaware Basin showing age, formation name, representative thickness, potential production zones, and approximate elevation and depth.

formations north of the Delaware Basin in the study area all contain zones of potential oil and gas production. Figure II-40 is a generalized section across the north edge of the basin showing equivalent rock units of Permian age north of the Capitan Limestone. All these rock formations have oil and gas potential.

Much of the oil and gas production north of township 21 South is from the relatively shallow Artesia Group (Figure II-40) below the Salado Formation.

Rock formations above and younger than the Delaware Mountain Group in the Delaware Basin and the Artesia Group, north of the Delaware Basin, do not contain appreciable quantities of hydrocarbons. Thus the Castile and Salado Formations and rock formations which overlie them are not important with respect to oil and gas.

(3) Salt Resources

Common salt, NaCl, occurs extensively in thick beds throughout the subsurface of eastern New Mexico. About 25 percent of the state is underlain by one or more salt beds. Salt occurs in the Castile, Salado, Rustler, Yeso, San Andres, Grayburg, Queen, Seven River's, Yates and Tansill Formations. In the study area, salt occurs mostly in the Castile, Salado, and Rustler Formations as bedded deposits, in brines in the lagunas such as Salt Lake, (Figure II-40), and in the brines and mineralized waters in the subsurface. These tremendous salt deposits are not extensively used, partly because many are impure but mostly because they are poorly located with respect to use areas they are not economically competitive with salt deposits located closer to industrial and population centers. One company near Carlsbad utilizes small quantities of salt.

(4) Aggregated Resources

Natural aggregate and crushed rock are widely used by the construction industry for concrete, road material, and ballast. Deposits of sand and gravel are relatively sparse in Eddy and Lea Counties, but these minerals have been quarried from the Floodplain of Dark Canyon near Carlsbad. The chief source of aggregate however, is crushed rock and caliche.

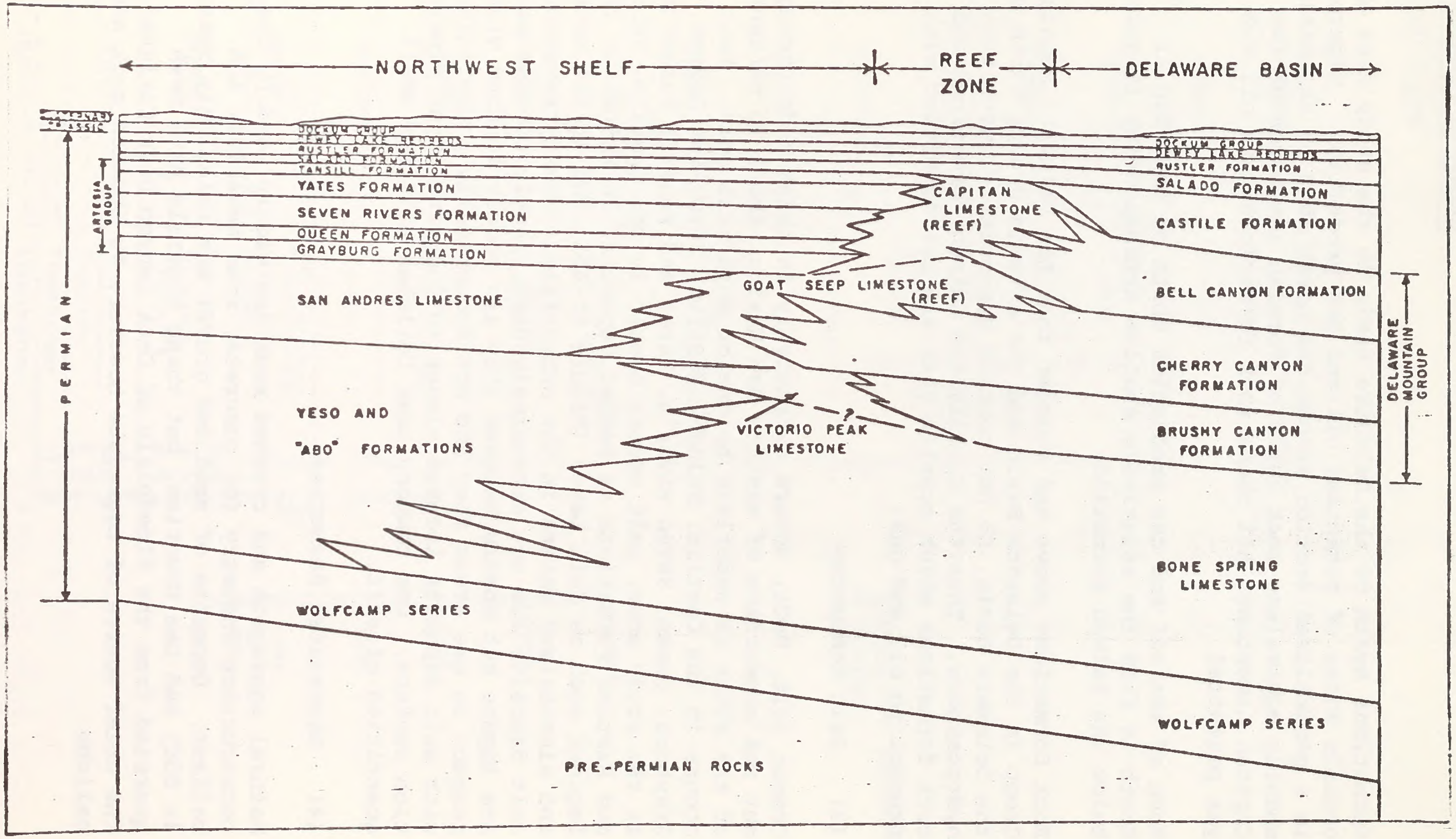


FIGURE II-40 Diagrammatic section of Formations of Permian age in the northern part of the Potash Study Area, southeastern New Mexico

Limestone and caliche suitable for use as aggregate are widely distributed in great quantity in Eddy and Lea Counties, although caliche is the chief source in Lea County. Resources are adequate, but the suitable deposits are not necessarily well located with respect to existing crushers or points where the aggregate is consumed. Aggregate for road and railroad construction is commonly obtained from nearby beds of caliche, processed through portable crushers and delivered on site. State and county road departments are processors and consumers of aggregate in addition to commercial operators.

At the end of 1974 there were 3 commercial operators from 4 quarries in Eddy County and 5 commercial operators from 5 quarries in Lea County. Most of these operations are outside the study area. Numerous quarries for caliche for road construction have been opened within the study area, but are not active at all times.

In addition, contractors may open pits and quarries or purchase aggregates from suppliers for the life of a construction project, then close or abandon the operation. Thus details of production statistics and quarry locations are not readily available.

3. Water

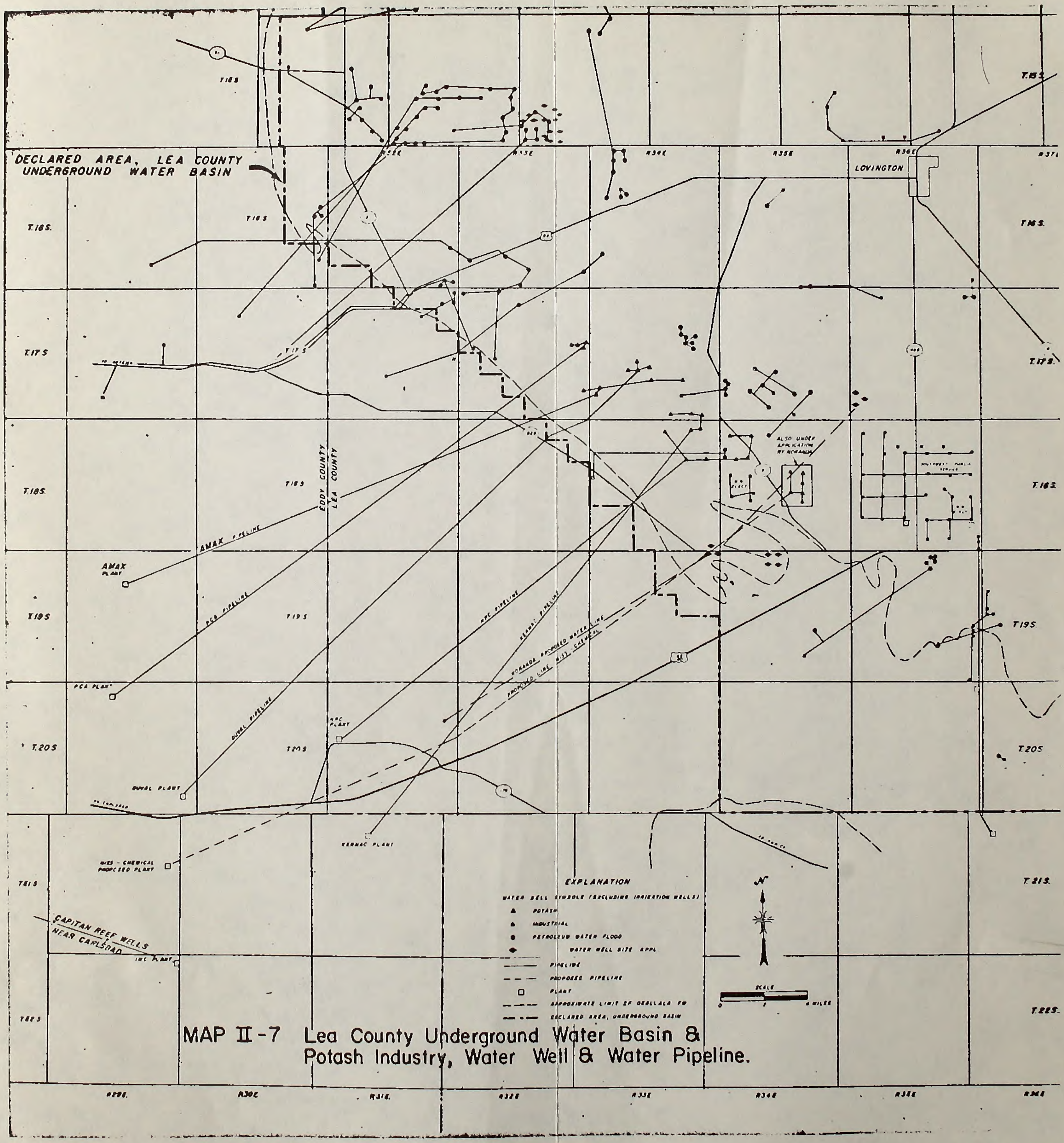
a. Water Supplies of the Potash Industry

Water used in mining and refining operations, is obtained principally from wells in the declared Lea County and Carlsbad underground water basins. One company has used water from the Pecos River. These sources of water are under the jurisdiction of the New Mexico State Engineer. Unappropriated water is still available in parts of the Lea County underground water basin, but water in the Carlsbad underground water basin and from the Pecos River is fully appropriated. Attempts to develop adequate supplies of water from the Rustler Formation have not been successful so far. Requests to obtain new appropriations of water from the Capitan Limestone of the Capitan underground water basin have been denied by the State Engineer on the grounds that impairment of existing rights would occur. In view of this situation, ground water in the Lea County underground water basin continues to be the best source of water for use by the potash industry. Procurement of additional water rights in the Lea County underground water basin would be in competition with agricultural, municipal, and commercial uses.

(1) Location and Accessibility of Supply

Five of the 7 potash companies own wells that are currently producing good quality water from the Ogallala Formation in the Lea County underground water basin. (See Map II-7, p. 169). The sixth, MCC owns wells in this area, but the wells are not being used. In the past this company's predecessor obtained water from the Pecos River. However, MCC is now using water from the Rustler Formation to operate their refinery. The seventh company, (IMC) obtains its water from wells that tap the Capitan Limestone at Carlsbad (T. 21 S., R. 27 E., Sec. 30) in the Carlsbad underground water basin.

The well fields in the Lea County underground water basin, locally referred to as "the Caprock," are in T. 17 S., Rs. 33, 34, and 35 E. and T. 18 S., Rs. 34 and 35 E. Straight-line distances between the refinery sites and their respective well fields range from 22 to 30 miles (Map II-7, p. 169). If additional well fields are needed in the future, it may be necessary to move greater distances eastward from the refinery sites toward places of greater saturated thickness of the aquifer. Acquisition of water rights would be involved.



MAP II-7 Lea County Underground Water Basin & Potash Industry, Water Well & Water Pipeline.

Water from the wells tapping the Capitan Formation at Carlsbad is piped about 17 miles eastward to the IMC refinery site.

(2) Character and Size of Supply

The Ogallala Formation in the Lea County basin contains beds of permeable sandstone and sandy conglomerate interbedded with lenses of claystone and siltstone. Information regarding the aquifer characteristics comes mostly from files in the Office of the State Engineer of New Mexico, and from Ash (1963). The present total saturated thickness of the Ogallala in the vicinity of the potash company well fields ranges from about 75 to 130 feet. Farther east, the saturated thickness is as much as 200 feet. Well yields in the potash company well fields range from about 200 to 1,000 gpm (gallons per minute) and probably average about 600 gpm. Pumpage has lowered the water table from a few hundreths of a foot per year to as much as 2.5 feet per year in some places. At the present rate of withdrawal the well fields could last from about 25 to more than 50 years.

The amount of recharge to the aquifer in the Ogallala Formation is a matter of controversy, and no attempt will be made to explain or extend this discussion. It is sufficient to quote from Nicholson and Clebsch (1961, p. 52) that, "A typical value for the rate of recharge to water-table aquifers in the Southern High Plains is about one-quarter to one-half inch of water per year. (Theis, 1937). In an aquifer with a porosity (ratio of void space to total rock volume) of 20 percent, this would raise the water 1¼ to 2½ inches per year, if there were no discharge whatever from the aquifer."

The source of water in the Carlsbad basin near Carlsbad consists of two wells that tap the Capitan Limestone at depths of 315 and 318 feet. These wells are reported to yield about 1,200 gpm, each and continued high yields can be expected for may years.

The Pecos River is only a fair water supply at the point of diversion near State Highway 31. During dry periods all or most of the water is diverted from the river for irrigation use. As stated previously, all of the Pecos River water has been appropriated.

(3) Quality of Supply

Water produced from the Ogallala Formation in the well fields of the Lea County basin is of good quality. Total dissolved solids range from 350 to 1,000 mg/l (milligrams per liter) and average from 500 to 600 mg/l.

Appreciable deterioration of the quality of the Ogallala Formation water is not likely to occur unless there are zones of poor quality that might contribute a sizable portion of the water during the later life of the aquifer, after the saturated thickness has been considerably reduced. Leaking pipe lines or deep wells should be avoided in order to prevent contamination of the aquifer from above or below. In one instance, leakage of salt water from a nearby oil well increased the chloride content of fresh water in T. 18 S., R. 34 E., Sec. 1 to an objectionable amount. Plugging of the leak and several months of pumping eventually restored the aquifer to its original good quality.

The quality of water in the Capitan Limestone, in the vicinity of the two source wells near Carlsbad, is fair. Total dissolved solids are about 2,500 mg/l and chlorides, about 300 mgl. Deterioration of this water has occurred during the last 30 years and deterioration is likely to continue as the good water to the west is pumped. This will allow water of poor quality to move in from the north and east. There is also the possibility of downward movement of poor quality water from the alluvium above the limestone aquifer, as well as upward movement of saline water from deep in the limestone aquifer.

The mineral content of water in the Pecos River, upstream from the brine springs at Malaga Bend, ranges from about 3,400 mg/l to 4,600 mg/l. The water is poorest in quality during periods of low streamflow.

(4) Quantity of Water Pumped

The total average annual pumpage for the 5 potash companies that use water from the Lea County basin is 8,500 acre feet. These companies could pump as much as 19,000 acre feet of water annually if the various permits were utilized to their fullest extent.

b. Introduction to Hydrology

The hydrology of the study area is related mostly to saline water or brine, and the physical characteristics of these hydrologic systems are complicated. This section will provide background data and information so that the reader can better assess and understand the technical scope of the problems.

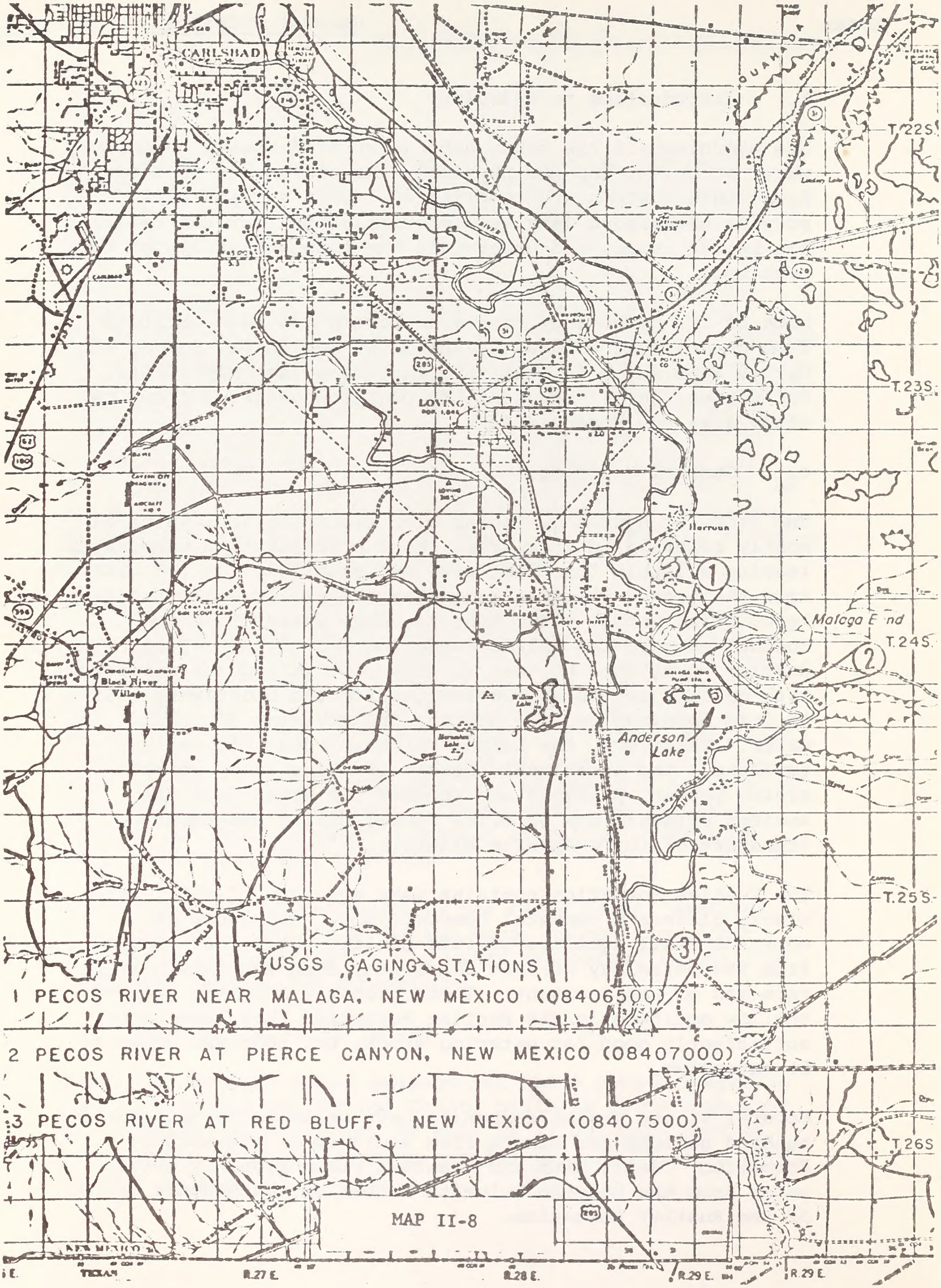
Much of the technology discussed herein has been obtained from unpublished studies by the U. S. Geological Survey at Malaga Bend which is near the study area (see Map II-8). For discussion of the chemistry of brine gathered from the study area see Appendix A-7.

c. General Hydrology

The story of hydrology begins with precipitation, which is mostly rainfall in this area. Most precipitation evaporates, leaving a little for plant use, and even less for percolation into the ground where it recharges the ground water aquifers. Percolating ground water does not move deeper than the contact between the Salado Formation and the overlying Rustler Formation, because in this zone it becomes saturated with halite, and is unable to dissolve the underlying salt to form openings for the storage and movement of ground water. Therefore, the Salado Formation does not contain aquifers. The occasional pockets of brine found while mining potash, probably are connate sea water from the ancient Delaware Sea or brine formed during subsequent transport of the evaporite minerals.

The Rustler Formation contains many aquifers of water with widely different chemical compositions. At places it contains small aquifers of fair quality water, but judging from the petrology of this formation, such aquifers must be rare and of small extent. There probably are many perched shallow aquifers in the Rustler Formation that have water sufficiently good for watering stock, but none are known to be extensive.

Several of the potash companies have wells yielding several hundred gallons per minute from aquifers in the Rustler Formation. Wells with the greatest yield probably obtain water from the Culebra Dolomite Member or the Magenta Member of the Rustler Formation.



USGS GAGING STATIONS

1 PECOS RIVER NEAR MALAGA, NEW MEXICO (08406500)

2 PECOS RIVER AT PIERCE CANYON, NEW MEXICO (08407000)

3 PECOS RIVER AT RED BLUFF, NEW NEXICO (08407500)

MAP II-8

Aquifers of the Rustler Formation are recharged partly from impounded water or brine in the numerous sinkholes or playa lakes, and the quality of recharge water can be judged from the extensive saline deposits covering their floors. It is supposed that these deposits are redissolved when the playas contain storm runoff; therefore, the quality of this recharge is poor.

The amount of recharge is small, even though the amount of stored saline water and brine is immense. It is likely that most of the brine in storage is in a very large aquifer at the base of the Rustler Formation.

The amount of natural saturated brine in Nash Draw was estimated at 625,000 acre-feet by Robinson and Lang (1938, p. 88). This estimate did not include that part of the brine aquifer in the Clayton Basin, and if this amount had been added, the total in storage may have equaled 1,000,000 acre-feet. This estimate also does not include all brine in Nash Draw. It is possible that if the extent of all brine aquifers had been known, the grand total of brine in storage would have been much greater. The only known discharge of the natural saturated brine aquifer is at Malaga Bend where it is presently pumped from Well USGS # 8 at the rate of about 700 acre-feet per year (See Map II-8, p. II-174).

This aquifer formerly discharged from brine springs at Malaga Bend and the amount of the discharge was estimated to be about 0.4 cubic feet per second or 300 acre feet per year (Hale and others, 1954, p. 2). Moreover, there is data indicating that the discharge of these springs was more or less constant for many years, suggesting that the recharge was about equal to the discharge.

Reports of observers indicate that some playa lakes in this area contain storm runoff for a much longer period than others, indicating that there may be more leakage from some than from others. From a study of Table II-61, aerial photos, and topographic maps, it is estimated that the total area of ephemeral and permanent lakes contributing recharge to aquifers in the Rustler Formation in Clayton Basin and Nash Draw is about 5,000 acres. Studies made by the U. S. Geological Survey at Malaga Bend indicate that annual storm runoff into Anderson Lake is about equal to precipitation. The average playa lake has a greater drainage area than Anderson Lake, suggesting a more reasonable ratio of storm runoff to precipitation of 2 or 3 to 1. Therefore, the

TABLE II-61

Surface areas of selected brine ponds and lakes in the Clayton Basin and Nash Draw, Eddy County, New Mexico

Areas from aerial photographs May 20, 1975 except Laguna Grande de La Sal - November, 1971)

Lake	Location Latitude (North) Longitude (west)	Sec., Township, Range	Area (acres)
Laguna Grande de Sal (Salt Lake)	32°18'40" 103°59'40"	Sec. 16, T. 23 S., R. 29 E.	2,570
Laguna Cinco	32°15'15" 103°56'45"	Sec. 3, T. 23 S., R. 29 E.	140
Laguna Quatro	32°20'15" 103°55'10"	Sec. 6, T. 23 S., R. 30 E.	200
Laguna Tres	32°20'15" 103°56'40"	Sec. 1, T. 23 S., R. 29 E.	370
Laguna Seis	32°20'35" 103°58'00"	Sec. 35, T. 22 S., R. 29 E.	80
Laguna Dos	32°20'40" 103°55'00"	Sec. 31, T. 22 S., R. 30 E.	35
Tamarisk Lake	32°21'00" 103°57'40"	Sec. 26, T. 22 S., R. 29 E.	75
Lindsey Lake	32°21'50" 103°57'00"	Sec. 26, T. 22 S., R. 29 E.	110
Laguna Uno	32°22'00" 103°55'10"	Sec. 24, T. 22 S., R. 29 E.	600
12 - Miscellaneous lakes in lower Nash Draw			166
Kerr-McGee brine ponds	32°29'20" 103°46'40"	Sec. 9, T. 21 S., R. 31 E.	45
	32°29'20" 103°46'50"	D.O.	65

S = 9,600 AF/yr.
SRO = 15,000 AF/yr.

25 M

TABLE II-61 continued

Mississippi Chemical Corp 3 - ponds	32°29'10" 103°56'10"	Sec. 12, T. 21 S., R. 29 E.	10
Duval 3 - ponds	32°32'10" 103°57'10"	Sec. 34, T. 20 S., R. 30 E.	60
Laguna Toston 2 - ponds	32°33'10" 103°46'55"	Sec. 20, T. 20 S., R. 32 E.	128
Williams Lake	32°34'20" 103°49'10"	Sec. 13, T. 21 S., R. 31 E.	35
National 11 - ponds	32°34' 103°49'	Sec. 18, T. 20 S., R. 32 E.	255
PCA 1 - brine lake	32°35'40" 103°59'15"	Sec. 8, T. 20 S., R. 30 E.	600
Other brine ponds			58
Clayton Lake	32°36'00" 103°57'10"	Sec. 3, T. 20 S., R. 30 E.	70
Hackberry Lake	32°38'10" 103°56'00"	Sec. 25, T. 19 S., R. 30 E.	20
Amax brine pond	32°39'20" 103°56'20"	Sec. 14, T. 19 S., R. 30 E.	30
TOTAL			5722

H_2O 5 X 5722 ≈ 28,000 AF

Plants 5 x 1000 ≈ 5000

Total Evap Loss. 33,000 AF

average annual storage in these playa lakes is in the range of 12,000 to 18,000 acre-feet, and it is obvious from this estimate that very little of the stored playa water percolates through the Rustler Formation to recharge the main brine aquifer. Recharge to aquifers in the Rustler Formation may be greater than formerly because of the numerous brine ponds which contain more or less permanent brine supplies, thus allowing more recharge at present.

The Dewey Lake Redbeds are not known to yield water to wells, although the possibility exists that small perched aquifers may exist in some of the thicker sandstone beds. Aquifers in rocks of Triassic age are not extensively exploited, but in large areas they may contain the only available water supply. In general, the quality of water in these rocks is better than that in the aquifers of the Rustler Formation, but at places it is known to be very saline.

The largest supply of good quality ground water is in the Ogallala Formation located to the east of the study area. This aquifer is the most important water supply for the potash industry.

There are may types of rock and surficial material of Quaternary age in the area, but little is known of their aquifers. Cooper (1962, p. 28) stated that the Gatuna Formation yields water of excellent quality to wells at places, but these aquifers are of limited occurrence. He further states that the water is usually of excellent quality. If there are aquifers in this formation within the Clayton Basin or Nash Draw with water of excellent quality, their locations are not known. Vine (1962) gives a log of a test hole in Sec. 34, T. 23 S., R. 30 E. in which the Gatuna Formation is about 35 feet thick and he states that this formation is at least 80 feet thick in Sec. 35, T. 19 S., R. 30 E. These thicknesses are sufficient to contain aquifers, but in the area of present mining such thick sections are probably of a local nature and therefore, the aquifers probably are not extensive. It is significant that the Gatuna Formation is missing or only a few feet thick in much of Nash Draw. Therefore, without evidence to the contrary, it must be assumed that most of its aquifers have contained nothing but saline water or brine during historical times. In other areas these aquifers may have economic potential, but the possibility has not been investigated.

The only other material of Quaternary age likely to have aquifers of enconomic importance, is the alluvium and most of this is to the west or south of the mining area and is in no danger of pollution by present or future refinery effluents. A spring (Sec. 4, T. 23 S., R. 29 E.) on the northern shore of Laguna Grande de la Sal, also known as Laguna Grande or Salt Lake, probably discharges from a alluvial aquifer, and this water is reported to have a dissolved solid concentration of about 10,000 milligrams per liter.

The most impermeable formation above the Salado Formation is the Dewey Lake Redbeds. This is evidenced in aerial photographs where arroyos tend to form where the redbeds are buried only a few feet or outcrop. In areas where the bedding planes of these rocks are undisturbed by collapse, they probably form a good floor for brine ponds.

Sinkholes are used commonly by the potash refineries as brine ponds and these features would appear to leak badly because of the rupturing of sediment beds that presumably increases vertical permeability. Evidence discovered by Nicholson and Clebsch (1961, p. 57) convinced them that vertical permeabiltiy was greater in the sinkholes, but apparently there was no significant recharge to the aquifers in rocks of Triassic age, because ground water moving down through the rocks in the sinkholes discharged into the underlying rocks of Permian age. Nicholson and Clebsch also theorized that groundwater has moved upward from aquifers in rocks of Permian age to the surface, (1961, p. 47), and they observed that at still other places, these sinks contained mud and silt which formed an almost impermeable barrier to pond leakage (p. 60). Apparently, the question of whether, how much, or in what direction a given brine pond leaks, can be settled only by data collection relating directly to the pond.

Additional information on aquifers of this area is given by Brokaw and others (1972, table 3). Nicholson and Clebsch, (1961), give information on ground water resources in southern Lea County, New Mexico, and Hendrickson and Jones, (1952) give additional information on ground water conditions in Eddy County, New Mexico. A map (fig. 3) in the latter report gives the general direction of ground water movement.

The hydrology of two lakes in this area has been studied intensely by the U. S. Geological Survey. The results of these studies provide evidence on the extent of leakage from brine ponds and brine lakes. The first of these studies was made many years ago, and the results are summarized by Cooper (1962, p. 35).

d. Hydrology of Laguna Grande de la Sal and Anderson Lake

(1) Laguna Grande de la Sal

Robinson and Lang (1938) made a careful study of Laguna Grande de la Sal and the area between it and Malaga Bend to determine if brine in the lake moved toward the Pecos River. The source of the water in the lake is precipitation, storm runoff, spring discharge and effluent from the refinery or the U. S. Borax and Chemical Company. Test wells drilled in the vicintiy of the lake contain water of a different type which is much lower chloride content in permeable formations below the bottom of the lake. These data indicated that the lake brine was not leaking downward into the brine aquifer. In addition, water levels in the test wells indicate a gradient towards the lake, indicating ground water movement into the lake, rather than away from it. Occasionally, artesian conditions are present which cause the water to flow above the top of the salt crust. Robinson and Lang (1938, p. 100) believed that these artesian conditions indicated that there is little or no percolation of the lake brine downward to the underlying Rustler Formation, as otherwise the artesian head would not exist.

Theis (1942, p. 71) found that generally, water levels in the Laguna Grande de la Sal lake are high in winter and low in summer, whereas, the head of the water in the brine aquifer is high in the irrigation season and low between irrigation seasons. He supports the conclusion of Robinson and Lang, that there is no connection between the lake and the brine aquifer.

(2) Anderson Lake

The base or normal low flow of the Pecos River below Santa Rosa, New Mexico, about 300 river miles to the north, is usually of such poor quality that it can be used only for irrigation, and at many places and times it is unfit even for this purpose. In general, the quality deteriorates with downstream movement. This decline in quality results from evaporation, from inflow from saline springs, and from saline return flow of irrigation water. Some hydrologists believe that the decline in quality in part results from the evapotranspiration of phreatophytes. At places, the salinity of returning irrigation water is increasing. When this flow is finally contaminated by natural saturated brine inflow at Malaga Bend, the quality of the base flow becomes so poor that this water is actually a detriment to downstream users. For several decades, hydrologists of the U. S. Geological Survey have studied the problem of Malaga Bend and finally it was decided that the inflow of this brine could be greatly reduced or possibly eliminated by pumping from the brine aquifer and by disposing of the pumped brine in some local depression where it would be stored and allowed to evaporate. A search was made for a suitable depression. Laguna Grande de la Sal was not available; hence attention was turned to the local, but less suitable depressions at Malaga Bend. Laboratory and field tests showed that these depressions would leak if used (Cox and Havens, 1961), and funds for treating their floors to prevent leakage were not available. It was decided finally to continue the project notwithstanding the leakage because it was believed, optimistically, that the leakage would be less than the natural inflow, and if so, a net gain in quality of the river water would be achieved.

The Northeast Depression, later named Anderson Lake, was selected as the repository for the pumped brine and enough construction money was available for plowing and compacting the bottom 52 acres of this lake floor before brine storage. The Water Resources Division of the U. S. Geological Survey was designated to determine the leakage from the lake. Pumping of brine began in July 1963.

Estimates of the leakage from saturated brine reservoirs can be made by several methods, but all are based upon a quantitative balance of inflow and outflow, where the inflow is the sum of brine plus fresh water inflow, for a given period. The outflow is the sum of evaporated brine plus leakage, with an appropriate correction for the change in brine storage for the period of the calculation.

The inflow of brine to Anderson Lake was continually measured, and the inflow of fresh water was estimated from rain gauge records. The reservoir floor was carefully surveyed and the capacity and surface area were related to a referenced lake stage. The evaporation was computed by several methods, but initially the method was a modified form of the evaporation pan method. Much effort was given to this study until December 1968. Some data collection has continued, but leakage rates have not been computed from these data.

For many years, surface water samples have been collected daily at gaging stations in the Malaga Bend area. One gaging station, Pecos River near Malaga, New Mexico, (08406500) is above the area of natural brine inflow, and a second, Pecos River at Pierce Canyon Crossing, near Malaga, New Mexico, (8407000) is below the area of brine inflow. Samples are collected also at a third gaging station -- Pecos River at Red Bluff, New Mexico (08407500), which is about 17 river miles downstream from the Pierce Canyon gaging station. The locations of these installations are shown on Map II-8, p. II-174. Chemical analyses of these samples can be used in conjunction with river discharges to compute the loads of salt or chloride passing these stations during an arbitrary interval. By comparing the annual loads of dissolved chloride at both sites, it is possible to estimate the amount of brine inflow in this reach. These data (Table II-62) give a comparison of leakage from Anderson Lake showing increased chloride loads in the river in the reach between the Malaga gaging station and the Pierce Canyon gaging station, and in the reach between the Malaga gaging station and the Red Bluff gaging station.

Figures in column four of Table II-63 indicate that not all of the leakage from Anderson Lake flows back into the Pecos River, but such a conclusion is not necessarily correct, because a better average correlation is obtained between leakage from Anderson Lake and change of chloride loads in the reach between the Malaga and Red Bluff gaging stations. There are several probable reasons for the poor correlation between leakage and chloride load increases in the reach between the Malaga gaging station and the Pierce Canyon gaging station, the most important being that brine flowing into the river above the Pierce Canyon gaging station is not thoroughly mixed with the normal base flow. Hence, samples of surface water collected at the Pierce Canyon gaging station are not representative of the mixture of brine and water passing this installation. It is obvious that the loads of dissolved chlorides in river water increased steadily during the first 5 years of operation at Anderson Lake, and are related to the loads of chloride leakage from the lake.

TABLE II-62

Estimated leakage from inflow, change in storage, and evaporation at Anderson Lake, Eddy County, New Mexico

(Values in Acre-feet)

$$L \simeq I + F - R - .859E$$

	Brine Inflow I	Fresh-water Inflow F	Change in reservoir storage R	Brine evaporation E	Leakage L
July - Sept. 1963	153	10	118	28	21
Oct. 1963 - Sept. 1964	680	28	216	316	219
Oct. 1964 - Sept. 1965	716	48	88	315	404
Oct. 1965 - Sept. 1966	668	117	87	280	455
Oct. 1966 - Sept. 1967	744	52	15	343	485
Oct. 1967 - Sept. 1968	733	65	8	306	526

TABLE II-63

Estimated loads of chloride in leakage from Anderson Lake, Eddy County, New Mexico (col. 1), compared to the increase in chloride loads in the reach between the gaging stations Pecos River near Malaga, New Mexico (08406500) and Pecos River at Pierce Canyon, New Mexico (08407000), (col. 2), and the reach between the gaging stations Pecos River near Malaga, New Mexico and Pecos River at Red Bluff, New Mexico (08407500) (col. 3).

Column 4 gives the ratio of column 2 to column 1, and column 5 gives the ratio of column 3 to column 1.

(Loads in Short Tons)

	1	2	3	4	5
Oct. 1963 - Sept. 1964	55,000	37,200	40,200	0.68	0.73
Oct. 1964 - Sept. 1965	101,000	66,400	158,000	.66	1.56
Oct. 1965 - Sept. 1966	114,000	79,900	107,000	.71	.94
Oct. 1966 - Sept. 1967	122,000	92,700	148,000	.76	1.21
Oct. 1967 - Sept. 1968	132,000	94,200	100,000	.71	.76
Average	105,000	74,000	111,000	.71	1.06

To convert these loads of chloride to common salt, it is necessary to multiply by a factor of 1.65.

Ironically, these data do not show that the experiment was a failure, they show only that Anderson Lake leaks badly. The reason for the large increase in loads of dissolved chloride is that it was necessary to pump the brine aquifer at a greater rate than the natural inflow of brine, and despite the large amount of evaporation of brine in Anderson Lake, (Table II-62, p. II-183) the leakage still exceeded the original rate of natural inflow, which was about 300 acre feet per year. There is evidence that the pumping of brine has greatly reduced the natural inflow of brine, and if a better receptacle were available for evaporating the brine, the base flow in the Malaga Bend reach would be of better quality.

e. Miscellaneous Lakes and Brine Springs

There are many natural lakes in the Clayton Basin and Nash Draw. Some contain fresh water, others contain saline water, and still others contain brines. Only a few of these lakes were examined and little is known of their hydrology. It is unlikely, however, that the salinity of water in most of the lakes has been affected by effluent from potash refining, and only those most likely to be affected by refinery effluents were examined. From studies of old aerial photos and maps, it appears that a few of these lakes contained water most of the time, but most were ephemeral lakes containing water only for a few weeks or months following heavy storm runoffs.

Maps used during this reconnaissance were inaccurate, making the location of sampling sites somewhat uncertain; moreover, more lakes were found than were shown on the maps, probably because of the heavy storm runoff during the autumn of 1974. Because of these complications and the limited time spent on the field reconnaissance, some lakes are not located as accurately as desirable.

In general, the larger natural lakes are in the lower part of Nash Draw, and only a few of these lakes were examined and sampled during the field reconnaissance. (See Table II-64) It is believed that most of these lakes were formerly ephemeral, but now contain a more or less permanent brine supply. Because most of these lakes are unnamed and others may be studied in the future, it is desirable to give a system of names that can accomodate added names. The system proposed is to use Spanish numbers for names. Accordingly, the following names are proposed:

Table II-64

MISCELLANEOUS BRINE LAKES

Lake	Latitude (north) Longitude (west)	Location, Sec, Town, Range
Laguna Uno	32°22'15", 103°56'00"	Sec. 24,T.22 S., R.29 E.
Laguna Dos	32°20'40", 103°55'00"	Sec. 31, T.22 S., R.30 E.
Laguna Tres	32°20'00", 103°56'40"	Sec. 1, T.23 S., R.29 E.
Laguna Quatro	32°20'10", 103°55'15"	Sec. 6, T.23 S., R.30 E.
Laguna Cinco	32°19'20", 103°56'45"	Sec. 3, T.23 S., R.29 E.
Laguna Seis	32°20'30", 103°58'00"	Sec. 35, T.22 S., R.29 E.
Laguna Siete	32°34'10", 103°51'50"	Sec. 15, T.20 S., R.30 E.

Lakes which have been named previously or which are within named sinkholes will retain these names as follows:

Lake	Latitude (north), Longitude (west)	Approximate Location Sec, Town, Range
Lindsey Lake	32°22'00", 103°57'10"	Sec. 26 T.22 S., R.29 E.
Tamarisk Lake	32°21'25", 103°57'40"	Sec. 26 T.22 S., R.29 E.
Williams Lake	32°34'20", 103°49'00"	Sec. 13 T.20 S., R.31 E.
Calyton Lake	32°36'10", 103°57'10"	Sec. 3 T.20 S., R.30 E.
Hackberry Lake	32°38"10", 103°56'00"	Sec. 25 T.19 S., R.30 E.

Most of the lakes or brine ponds built specifically to receive effluents are named after the potash refinery such as "AMAX Brine Lake."

(1) Ponds and Lakes in the Clayton Basin Quadrangle

Hackberry Lake (Sec. 25, T. 19 S., R. 30 E.) contains the best quality of water found in this survey (Table II-63). This water is of quality better than would be expected from most aquifers in the Rustler Formation, and its location with respect to the AMAX brine pond (Sec. 14, T. 19 S., R. 30 E.) is significant because Hackberry Lake is about 2 miles downstream and its water level is about 80 feet lower than the brine level of the AMAX pond. Such circumstances suggest that there is little leakage from the AMAX brine pond. Hackberry Lake was accidentally polluted several years ago by a break in the dam forming the AMAX pond. Evidently the lake was not polluted badly, or nature has rinsed away most of the evidence. Its surface area was about 20 acres (Table II-61, p. 176).

An unnamed lake in Sec. 13, T. 20 S., R. 31 E., herein named Williams Lake, was sampled. This lake supported many wild fowl. Its salinity is about equal to that of sea water and its surface area is about 35 acres.

A lake located in Sec. 1, T. 20 S., R. 30 E., (Laguna Siete) was sampled. This lake was obviously ephemeral because of the large amount of brush in and surrounding it.

The waters of Clayton Lake have been analyzed by employees of AMAX Chemical Corporation and some of these analyses are given in Appendix A-7. The total salinity of the lake is perhaps twice as great as would be expected, but the potassium concentration is several times greater than expected. These analyses indicate progressive pollution but some of the increase in concentration is due to evaporation. Despite this pollution, the lake is not too saline to support many forms of marine life. This salinity which is less than that of sea water, is no greater than occasional base flow in some reaches of the Pecos River.

Several brine effluent ponds and lakes were sampled and chemical analyses are given in Table II-65. The largest of these lakes, the PCA brine lake, was the only one containing undersaturated brine, and this is due probably to dilution by storm runoff. The amount of effluent flowing into these lakes was neither measured nor estimated.

(2) Ponds and Lakes in the Nash Draw Quadrangle

Aerial photos taken over a period of more than 20 years, and old maps show that the lakes in lower Nash Draw are increasing in size with time. The brine levels of Lagunas Tres and Quatro, and perhaps others have risen to such levels that it has been necessary to raise the roadbed of New Mexico State Highway 128 once or twice. Laguna Uno contained no brine in photos taken in April 1954, but a revised edition of the U. S. Geological Survey Nash Draw Quadrangle (1965) shows about 200 acres of brine in the lower part, and an aerial photo taken in November 1971 shows only slightly less. It is assumed that these are all water level lakes or windows allowing a view of an underground aquifer. The

Table II-65

Nash Draw + Adjacent Areas

Concentrations of selected constituents in samples of water and brine in eastern Eddy County, New Mexico

Analyses by U. S. Geological Survey

Source	Location Latitude (North) Longitude (West)	Date of Collection	Concentration (milligrams per liter)						
			Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulphate (SO_4)	Boron (B)	Bromide (Br)	Dissolved solids
Anderson Lake	32°11'55" 104°00'35"	4-18-75	120,000	5,000	190,000		25.0	40	
Well USGS No. 8	32°13'05" 103°59'51"	4-18-75	91,000	3,500	140,000		15.0	30	
Laguna Grande	32°19'00" 103°59'30"	4-17-75	120,000	11,000	200,000		8.7	80	
Surprise Spring	32°19'40" 103°59'35"	4-19-75	110,000	11,000	170,000			70	
Laguna Quatro	32°20'15" 103°55'10"	4-16-75	57,000	12,000	100,000		.9	50	
Laguna Tres	32°20'15" 103°56'40"	4-16-75	53,000	8,800	97,000		3.7	40	
Tamarisk Lake	32°21'00" 103°57'40"	4-18-75	82,000	16,000	150,000		4.9	60	
Lindsey Lake	32°21'50" 103°57'00"	4-17-75	82,000	17,000	150,000		5.9	100	
Laguna Uno	32°22'00" 103°55'10"	4-16-75	94,000	20,000	172,000		11.0	50	

Table II-65 continued

Concentrations of selected constituents in samples of water and brine in eastern Eddy County, New Mexico

Analyses by U. S. Geological Survey

Source	Location Latitude (North) Longitude (West)	Date of Collection	Concentration (milligrams per liter) Sodium (Na)	Potassium (K)	Chloride (Cl)	Sulphate (SO_4)	Boron (B)	Bromide (Br)	Dissolved solids
Brine Spring	32°23'40" 103°55'45"	4-18-75	56,000	12,000	100,000		5.3	40	
Effluent IMC refinery	32°23'40" 103°56'05"	4-18-75	100,000	30,000	190,000		12.0	60	
Kerr-McGee brine pond	32°29'00" 103°47'20"	4-22-75	110,000	21,000	186,000		35.0	80	
Effluent Kermac	32°29'00" 103°47'20"	4-22-75	120,000	11,000	180,000		23.0	40	
Miss. Chemical brine pond	32°29'25" 130°56'20"	4-18-75	97,000	50,000	200,000		38.0	130	
Composite sample of water from 3 wells tapping Rustler formation Miss. Chemical plant	32°29'25" 103°56'20"	4-18-75	27,000	3,800	54,000		12.0	20	
Duval brine pond	32°32'10" 103°57'10"	4-19-75	95,000	43,000	190,000		40.0	100	
Laguna Siete	32°34'10" 103°57'50"	4-19-75	3,200	310	8,400		3.3	10	

TABLE II-65 continued

Concentrations of selected constituents in samples of water and brine in eastern Eddy County, New Mexico

Analyses by U. S. Geological Survey

Source	Location Latitude (North) Longitude (West)	Date of Collection	Concentration (milligrams per liter) Sodium (NA)	Potassium (K)	Chloride (Cl)	Sulphate (SO_4)	Boron (B)	Bromide (Br)	Dissolved solids
Williams Lake	32°34'20" 103°49'10"	4-18-75	12,000	3,500	22,000		1.7	15	
National brine pond	32°34'20" 103°~~59~~'~~15~~" 40'' 48'	4-18-75	99,000	31,000	200,000		9.9	210	
PCA brine lake	32°35'40" ~~130~~°59'15" 103	4-19-75	45,000	21,000	86,000		4.7	40	
Hackberry Lake	32°38'10" ~~130~~°56'00" 103	4-20-75	340	150	500		.2	9	
Amax brine pond	32°39'20" ~~130~~°56'00" 103°	4-19-75	100,000	29,000	190,000		6.0	60	

thickness of this aquifer cannot be determined without substantially more data collection.

Since the time of the Robinson and Lang study, it has been known that a saturated brine aquifer underlies this area, but at that time it was believed that the top of this aquifer was 200-250 feet below land surface. If this is true, it does not necessarily follow that the interval between the brine aquifer and surface of the lakes has filled with brine. It is more probable that the brine aquifer feeding these lakes is a thin perched aquifer, because there has been no new source of brine abundant enough to fill the entire interval. It is likely that there were unreported shallow brine aquifers even in 1938, because a map (Robinson and Lang, 1938, p. 93) shows several brine springs along the eastern edge of Laguna Grande de la Sal.

It is shown by Cooper (1962, table 2), that Nash Well, Sec. 6, T. 23 S., R. 30 E., was 30 feet deep and the water level was 6.5 feet below land surface. This well is now flooded by Laguna Quatro, hence the aquifer below this lake has risen at least 7 feet since August 19, 1958. If the reported depth is correct, the aquifer may have risen 30 feet since the time it was drilled, because presumably it did not pump brine when drilled.

An attempt was made to determine the gradient of the present shallow brine aquifer by measuring the altitude of the lakes in lower Nash Draw. The altitude measurements were with aneroid barometers which failed to operate correctly. For this reason the gradient was not obtained, but the measurements were sufficiently good to determine the direction of the gradient. From the north and east, the gradient of the brine aquifer slopes toward Laguna Grande de la Sal, indicating that it is now discharging into that body of brine from both directions. A map (Robinson and Lang, 1938, p. 93) shows several brine springs along the eastern edge of Laguna Grande de la Sal.

Investigations for this report indicate that there are probably saline aquifers above the brine aquifer in the vicinity of the brine lakes, Laguna Tres and Quatro. These aquifers may be ephemeral, drying up during long periods of drought; however, they probably exist during much of the year. It has been noted that quail drink from these lakes. This would indicate that there may be saline springs providing water to the surface. Records on Nash Well waters report there was a marginal saline aquifer in the area prior to encroachment by the dense brines which appear to be seeping southward from the potash refineries. The potash refinery brines probably sink during their southward flow, allowing a portion of the lighter saline waters to ride above the dense brine.

Some of the lakes in lower Nash Draw have surface connections, and field observations indicate that these connections were better and more numerous when the lake stages were higher at some earlier date. At other places where there are no surface connections, the lakes are separated commonly by rocks with large porosities or transmissivities, and with such conditions there must be a significant transfer of brine by ground water movement.

(3) Brine Springs

Two brine springs were sampled, an unnamed spring below salt tailings in Sec. 18, T. 22 S., R. 30 E., (Lat. 32°23'40", Long. 103°55'45"), and a spring known as Surprise Spring, (not necessarily the Surprise Spring in the Robinson and Lang report, even though located in the same vicinity Sec. 4, T. 23 S., R. 29 E., or Lat. 32°19'40", Long. 32°59'35"). It was thought that the unnamed brine spring was discharging effluent that had percolated down through the salt tailings but the chemical analyses in Table II-65, p. 190 , shows that this theory is incorrect. The source is not known. Discharge from this spring was very small, less than 1 gallon per minute.

Surprise Spring discharges into Laguna Grande de la Sal from beneath the lake surface, and consequently the amount of discharge is unknown. Judging from the boil on the lake surface, this discharge must be at least a few hundred gallons per minute. The chemical composition of this brine does not resemble closely the composition of brine in any of the nearby lakes, therefore, its source is unknown. The dissimilarities in composition between the surprise spring brine and the lake brines may be due to the fact that the brine had been in storage for several months.

Above the confining beds of Surprise Spring, and a few yards distant is another spring which discharges saline water. This water is reported to have a total dissolved solid concentration of about 10,000 milligrams per litre, and its quality is good enough to support aquatic vegetations, frogs and minnows. It is possible that this spring is the Surprise Spring in the Robinson and Lang report. Its discharge is probably only a few gallons per minute.

f. Evapotranspiration and evaporation from tailings piles

If the estimated evaporation of the brine ponds and lakes near the potash refineries is subtracted from the refinery effluent from the refineries, there will be a large apparent leakage even with estimates of change in storage of the reservoirs. Previous investigators (Gilkey and Stotelmeyer, 1965, p. 11-26) have assigned this deficit to seepage or leakage, but it is suggested that their calculations may not provide a good estimate of reservoir leakage.

Thick stands of phreatophytes, mainly tamarisk or salt cedar, grow along the banks of many of the brine reservoirs, and these plants are notorious water users. It is known that salt cedars transpire to the atomosphere large amounts of very saline water, but the limit of salt tolerance is unknown. Their presence in such hostile environments suggests that there may be no limit to their salt tolerances. An indeterminate part of the previously assigned leakage should be reassigned to evapotranspiration by phreatophytes.

The large tailings piles are contributing greatly to brine evaporation. At some refineries, it appears that there is a deliberate attempt to utilize the salt piles for evaporation, while at others there is little effort to manage these features. These huge tailings piles are attractive evaporators for several reasons. Their sloping surface areas are much greater than the land area covered, and their surfaces are rough, exposing a greater area for evaporation than a comparable liquid or reservoir surface. Another advantage is that the pan coefficient for evaporation is probably greater, allowing greater evaporation per unit area than on a reservoir surface.

Infrared aerial photos were studied in an effort to delineate the areas of salt piles contributing to evaporation, but this effort was only partly successful. The photos were taken on a day of strong surface winds and reflections from waves interfered greatly with the interpretation; moreover, it was noted that the near vertical walls of some salt piles were wet and it was impossible to estimate these areas. Nonetheless, the study does provide a minimum area of about

1,000 acres contributing to evaporation. The annual evaporation from an acre of salt tailings must be at least 5 feet; hence the estimated evaporation from the salt piles is at least 5,000 acre feet per year.

g. Brine effluent in the hydrologic cycle

The amount of brine effluent from the potash refineries can not be estimated with confidence. A questionnaire was circulated to all potash refineries requesting this information but the data received are believed to be questionable because of the difficulty in measuring brine slurry flows containing high concentrations of solid salt and clay slimes. Thought should be given to methods of measuring these values, but the technology may be moderately difficult because of different methods of slime, salt, and brine disposal. At Malaga Bend, where the problem of measuring brine inflow to Anderson Lake is relatively simple, the inflow for any given period is known probably with accuracy of ±5 percent. With less favorable conditions, where the brine is mixed with slimes or salt tailings, it is unlikely that measurements of this accuracy can be attained. The problem is further complicated at some refineries where brine is recirculated either directly or indirectly, and the net amount of effluent that affects the hydrologic cycle is difficult to estimate.

For this report it is guessed that the brine effluent is in the range of 80 to 90 percent of the total water supply to the refineries. The amount of fresh water used by the potash refineries is probably about 12,000 acre-feet per year, and the amount of brine pumped from local wells penetrating the Rustler Formation is much less, but probably a significant part of the total. It is guessed that this part may be 5 to 10 percent of the total and an indeterminate amount is recycled brine, possibly leakage from brine ponds. In view of this situation, it is best, if not altogether appropriate, to ignore this part of the water budget, and estimate the amount of brine effluent affecting the environment at 9,600 to 10,800 acre-feet.

The concentration of potassium in the effluent brine varies considerably with the type of plant operation and these values are generally lower at those refineries that use local water for flushing tailings. The average concentration for those plants that do not utilize a local water supply is about 20,000 to 30,000 milligrams per litre, based on chemical analyses or assays furnished by the refineries. Brine analyses in Appendix A-7 show that these values are about correct when allowance is made for evaporation or dilution with storm runoff. If an average concentration or 25,000 milligrams per litre is asumed, it is estimated that the loss of potash (K_2O) in effluent brine is about 500,000 tons per year.

Two attempts have been made to analyze the circulation of water and brine in the processing of potash ores. Gilkey and Stotelmeyer (1965) attempted to estimate the amount of evaporation and effluent discharge in various plant operations, and from water and brine budgets they estimated leakage from the brine ponds.

A second attempt to estimate the brine effluent from the potash refineries was made by Irby (1967). This report probably had access to better data, but no attempt was made to estimate leakage from the brine ponds.

There are many problems in estimating leakage of brine ponds from water and brine budgets. Evaporation ranges within an order of magnitude from winter to summer. For example, brine pan evaporation at Malaga Bend was measured at 0.144 feet during January 1966, but this figure leaped to 1.146 feet for July 1966. Values of brine pan evaporation for 1968 ranged from 0.078 feet in January to 1.029 feet in July. Even if the amount of effluent is known precisely, allowance must be made for evaporation on the salt piles and for the amount of brine recycled directly or indirectly through pumping of local aquifers, and if all of this is known, further allowance must be made for changes in storage of the brine ponds. Because storage is continually depleted by the accretion of slimes and salt, its precise value cannot be calculated without great effort. Unless all factors involved in this precarious balance are evaluated precisely, it is possible that the values of leakage contain more errors than fact.

Anderson Lake is poorly sited, and as a result a great amount of leakage occurs. Studies have indicated about 72 percent of the brine inflow leaves the lake as leakage. There is evidence that it may be much lower at present; therefore, estimates of greater leakage from some ponds that appear to be better sited should be viewed with skepticism. Surficial evidence of significant leakage from effluent brine ponds and lakes was noted only at Laguna Uno. Elsewhere the surficial evidence that could be found such as that previously cited for the AMAX brine pond, and in a dry quarry a few yards from a National pond suggest no significant leakage.

Leakage values from the brine ponds can be calculated if data are collected for that purpose, but the effort would require 6 man years and an estimated $300,000.

The quality of ground water beneath most of the brine reservoirs was never good. Therefore, if this saline water is being polluted with brine effluent at places, returning it to its pristine condition will have achieved scarcely any economic benefit. Because of the hydrologic environment of the Rustler Formation, any good guatity water supply will probably deteriorate in quality with sustained pumping, and the reason is not always due to pollution from effluent brine. In most cases the reason is that the good water is being replaced with the more abundant saline or very saline water.

There is very little fresh water in this area, but there is enough slightly saline ground water to be of economic importance. Most of the fresh water is in "surficial" deposits, and wells tapping this source tend to be less than 100 feet deep. (Jones and others, 1973, table 4). The more abundant and useful saline water is mostly in rocks of Triassic age, with some possible aquifers in the Dewey Lake Redbeds. It is doubtful if yields from wells tapping these aquifers will be greater than a few hundred gallons per minute, and most will yield much less, but still they may become a valuable resource. A map showing the subsurface distribution of the Dewey Lake Redbeds and Triassic rocks undifferentiated is given by Brokaw and others (p. 29). This map shows that these rocks dip to the east and it would be assumed normally that the ground water movement is in the same direction. It is noted also that most of the potash refineries and brine ponds are within a few miles of areas where these rocks are in the subsurface, therefore, there might be a possibility that aquifers in these rocks are being polluted with refinery effluent.

Data given by Nicholson and Clebsch (1961, p. 2) suggest, however, that such an assumption is incorrect. Their data show that there is little if any recharge to these aquifers from the area of potash mining. These data indicate, that ground water movement is toward the Clayton Basin and Nash Draw; therefore, it is assumed that these aquifers are not being polluted by refinery effluents.

From field observations it was decided that the poorest geologically sited brine pond is Laguna Uno, which is receiving the effluent from the IMC refinery. This reservoir is separated from Lindsey Lake by a low ridge of cavernous gypsum which averages about 500 yards in width for a distance of about 400 yards. With such a leaky barrier, it might be assumed that the brine levels of Laguna Uno and Lindsey Lake would be about equal, but this is untrue. At the time of these observations, the brine level of Laguna Uno was about 15 feet higher than the brine level of Lindsey Lake; moreover, the chemical analyses of brines in these lakes (Appendix A-7) have enough dissimilarities to suggest that the ground water connection is less than perfect. Brine from Laguna Uno does leak into Lindsey Lake, but any notion that the flow is practically unrestricted, is erroneous.

It is instructive to compare the evaporation of lakes in lower Nash Draw with the nearest source of brine effluent, the IMC refinery. It is estimated by IMC officials that their effluent is about 90 percent of total water consumption. This amounts to about 5,000 acre-feet of brine per year, which is about 30 percent of the total consumption of fresh water for all refineries. This estimate was confirmed by a field estimate of effluent inflow to Laguna Uno of 5 to 10 cubic feet per second, as compared to a calculated value of 6.9 cubic feet per second, based on the IMC estimate. The surface area of new lakes in lower Nash Draw is estimated at about 1800 acres, which is sufficient to evaporate about 8,000 acre-feet of brine per year or 3,000 acre-feet in excess of the estimated discharge from the IMC refinery.

Although the leakage from brine ponds and lakes cannot be estimated with available data, it is safe to assume the total is significant enough to affect the water and brine levels of aquifers in the Clayton Basin and Nash Draw. Some saline water and brine is withdrawn from these aquifers by stock, domestic, and refinery wells, but withdrawals probably are much less than reservoir leakage. It is an inescapable conclusion that this increase in recharge must result eventually in an increase in discharge from these aquifers. The points of this discharge are only speculative. Data given by Brokaw and others (1972, fig. 8) indicate that a probable avenue for brine movement is down a ground water trough in the Clayton Basin to an adjoining trough in Nash Draw, and thence down to the lakes in lower Nash Draw.

It is possible that brine reservoir leakage in the Clayton Basin has already contributed to the increase of brine storage in the lakes in lower Nash Draw by increasing the hydraulic head or pressure on aquifers throughout the area. It is theorized that the brine lakes in lower Nash Draw will grow in size until they are capable of evaporating most of the effluent. They will continue to grow if greater amounts of effluent flow into the area, until they overflow into Laguna Grande de la Sal, and when they have reached this stage, growth will stop because the large surface area of Laguna Grande de la Sal is sufficient to evaporate about 15,000 acre-feet of brine per year. The new lakes probably will not grow much larger because the present stages are nearly sufficient to establish surface connections to Laguna Grande de la Sal. Field observations indicate that these lakes may have already reached their maxiumum sizes, probably during the storms in the Autumn of 1974.

The question of whether potash refinery brine effluent is flowing into the Pecos River is important. It is not likely that effluent has reached the river. This claim is based on several lines of reasoning. Groundwater movement is normally slow, and in Nash Draw, the rate of movement is probably only a few tens or hundreds of feet per year. Also, the elapsed time since the beginning of potash refining is only a few decades.

From a study of chemical analyses in Table II-65, p. 188 it is seen that those brines with salinities comparable to the brines from Well USGS #8 and Anderson Lake have much greater potassium and bromide concentrations, reflecting their association with potash refining. This evidence, coupled with the fact that there has been no discernible increase in potassium concentrations of the brine from USGS #8 during the long history of its study, shows that effluent from the refineries has not yet polluted the Pecos River. The bromide concentrations of this brine have been determined for only a short time and can not be used as evidence.

Although the effluent has not reached the river, it is possible that some of this brine may be percolating down to the main brine aquifer and causing an increase in the piezometric pressure on this aquifer. Under such circumstances, the natural flow of brine toward Malaga Bend could be increasing, but there is no evidence, save circumstantial, to justify such a claim. If the studies in the area of Malaga Bend were intensified to the former level of effort during 1963-68, it is possible that data relating to this problem might be collected.

B. Living Components

1. Vegetation

Within southeastern New Mexico, the specific vegetative community present at any location is highly dependent upon such soil characteristics as infiltration rate of the surface soil, depth of soil to a restrictive layer, and the extent to which the surface soil has been reworked by wind or water erosion. Because vegetation is so dependent upon soil, vegetative communities are discussed according to soil groups. (See Appendix A-8 for classifications and descriptions of soil groups).

The annuals present at any specific location during any year are determined to a large extent by the timing when sufficient soil moisture is available for germination, i.e., moisture received by the deep sands area in March through May will generally produce an abundance of spectacle pod and western ragweed, while if the same area does not receive adequate soil moisture until June or July, sunflowers may be the dominate annual. (See Appendix B-1 for scientific names of the common plant names given in the text.)

In general, each soil and its associated climatic conditions will sustain a certain percentage of live vegetative ground cover. During years of above average rainfall, the voids between the resident plants become occupied by other species. In many cases, with two or more years of above normal precipitation, these new occupants may be perennial grass plants, such as mesa dropseed and plains bristlegrass.

a. Soil Group I

Within the Soil Group I area, the vegetation ranges from that characteristic of deep soils to that of very shallow ridges. Approximately 15 percent of these areas are characterized by swales and karst holes which contain deep alluvial soils occupied by mesquite brush. Moving upward on the landscape, mesquite gives way to catclaw on the more sandy soils, and gives way to creosote bush on the shallower, more loamy textured soils.

The swales and karst hole bottoms are generally densely vegetated because they receive additional water from the micro-watersheds above them. Perennial grasses within these areas are black grama, plains bristlegrass, hooded windmill grass, and vine mesquite, with a sprinkling of cane bluestem and mesa dropseed.

The annuals present during 1975 were desert baileya, desert verbena, pepperweed, croton and broom snakeweed.

As one moves upward on the landscape, the soils become more mesic because of their depth, water holding capacity, and slope. Because of their position, these soils serve as watersheds for the swale bottoms and karst holes and contain much less vegetative ground cover.

The intermediate area, between the drainage bottoms and the ridge tops are occupied by creosote brush with scattered catclaw bushes and occasional yucca plants.

Perennial grasses are very limited in these areas and are largely bush muhly within the creosote bush clump and in areas of slight depressions or other water ponding areas. During some years mesa dropseed will occur in those areas where water is retained, and therefore a better soil moisture regimen occurs.

During 1975 there was an excellent stand of annual broadleaf plants. This was the result of abundant precipitation which occurred from August 1974 through January, 1975. The annuals present were pepperweed, bladder pod, desert baileya and bahia. Where there is sufficient soil depth, broom snakeweed occurs; however, on the shallow soils it does not occur with any degree of regularity.

b. Soil Group II

The soils within Soil Group II have gypsum material either exposed or at relatively shallow depths, and as a result the vegetation present is to a large degree dependent upon the depth of gypsum soils. In small isolated areas, a high water-table of non-potable water occurs during some parts of the year.

The higher position on the landscape is occupied by gyp grama and ring muhly, with a sparse stand of creosote brush and tasajillo cactus and occasionally a fourwing saltbush. Prickle pear cactus and yucca plants occur as widely spaced individuals within these areas. The most common occurring perennial half shrub is broom snakeweed.

Several annual broadleaf plants occur on these sites with pepperweed and rayless goldenrod as the most common.

In proximity to several salt lakes there are pockets of deeper soils which probably have a high water table during some parts of the year. These areas have excell ent stands of alkali sacaton with fourwing saltbush and/or salt cedar occurring. In some of the areas salt cedar is lacking and mesquite is dominate.

c. Soil Group III

The vegetative aspect of Soil Group III is that of shrubs, comprised of shinnery oak, sand sage, yucca and scattered mesquite. The perennial grasses present at any spot are, to a great extent, dependent upon the clay content of the surface soils. Sandy loam or loamy sand areas generally support dense stands of black grama as the dominant grass species and generally have little if any shinnery oak. These soils do support dense stands of mesquite brush. Bush muhly is generally present within the perimeter of small mesquite bushes until they can no longer compete for moisture. Then very little if any understory is within the mesquite clumps.

The soils of Group III which have been greatly reworked by winds and are classified as sandy, are occupied by grasses such as the dropseeds, harvards three-awns and stipas. These areas have an aspect of shinnery oak on the highly reworked soils, and sand sage and yucca on the soils reworked to a lesser degree.

Various species of dropseed grasses and harvards three-awn make up the most conspicuous composition of grasses. In years of favorable precipitation, an understory of short grasses such as fall witch grass, halls panicum and scribners panicum will comprise approximately equal portions of the total grass composition.

Annuals such as spectacle pod, sunflowers, and western ragweed are present when favorable soil moisture is present.

d. Soil Group IV

Group IV soils vary in depth and texture with elevation. The lower soils have a more sandy texture and the higher elevations have a more loamy texture being shallower with exposed caliche pebbles (less than 2 inches in diameter) scattered on the surface. The vegetation varies much like the soils.

The deeper, lower portion of the group are much the same as the bottoms in soil Group I, with the exception that they receive very little, if any, additional run-in moisture, therefore, the ground cover is much less.

The aspect of these lower areas is that of mesquite brush with a scattering of fourwing saltbush. The area is characterized by coppiced sand dunes upon which the mesquite brush grows, and subsoil is exposed in the dune interspaces. Perennial grasses on the coppiced dunes are mainly dropseeds and plains bristlegrass with an occasional black grama and bush muhly. Broom snakeweed and lemon weed occupy the exposed subsoil areas.

The higher elevations aspects, although still occupied by mesquite brush, are also occupied by javelina bush, feather peabush, catclaw, allthorn and yucca. The annual broadleaf vegetation includes bladder pod, croton, and broom snakeweed. The perennial grasses occurring are black grama, mesa dropseed and harvards three awn. Within the perimeter of most javelina bushes and many low growing mesquite plants, there are usually colonies of bush muhly.

e. Soil Group V

Soils of Group V generally occur on the low ridge tops within the area, and in many cases have caliche pebbles exposed on the surface. The vegetative aspect is that of a desert shrub or a combination of shrubs. The shrubs occurring will generally be mesquite with a very sparce stand of creosote brush or catclaw interspaced, or the shrubs will be a mixture of allthorn, catclaw and javelina bush.

In those areas where creosote brush is the major predominant shrub, the perennial grasses are fluff grass with black grama, and mesa dropseed occurring in sparse scattered stand. Bladder pod, lemon weed and sometimes desert verbena make up the majority of the annual broadleaf plants, while six weeks grama and purple three-awn may occur as annual grasses.

On those areas where a mixture of catclaw, javelina bush, allthorn and others occur, the perennial grasses are generally tridin sp., mesa dropseed, and one of the gramas in sparse stands. Bladder pod, lemon weed or spectacle pod will generally be the annual broadleafs occurring in association with Group V grasses.

f. Soil Group VI

The playas of Soil Group VI themselves are barren of vegetation, although a band of varying widths of alkali sacaton and salt cedar occur around the playas above the waterline. In areas indurated only during certain years, pickleweed or some other extremely salt tolerant species may occur. Adjacent to these playas are vegetative communities similar to those described in Soil Group II.

2. Wildlife

a. Aquatic Wildlife

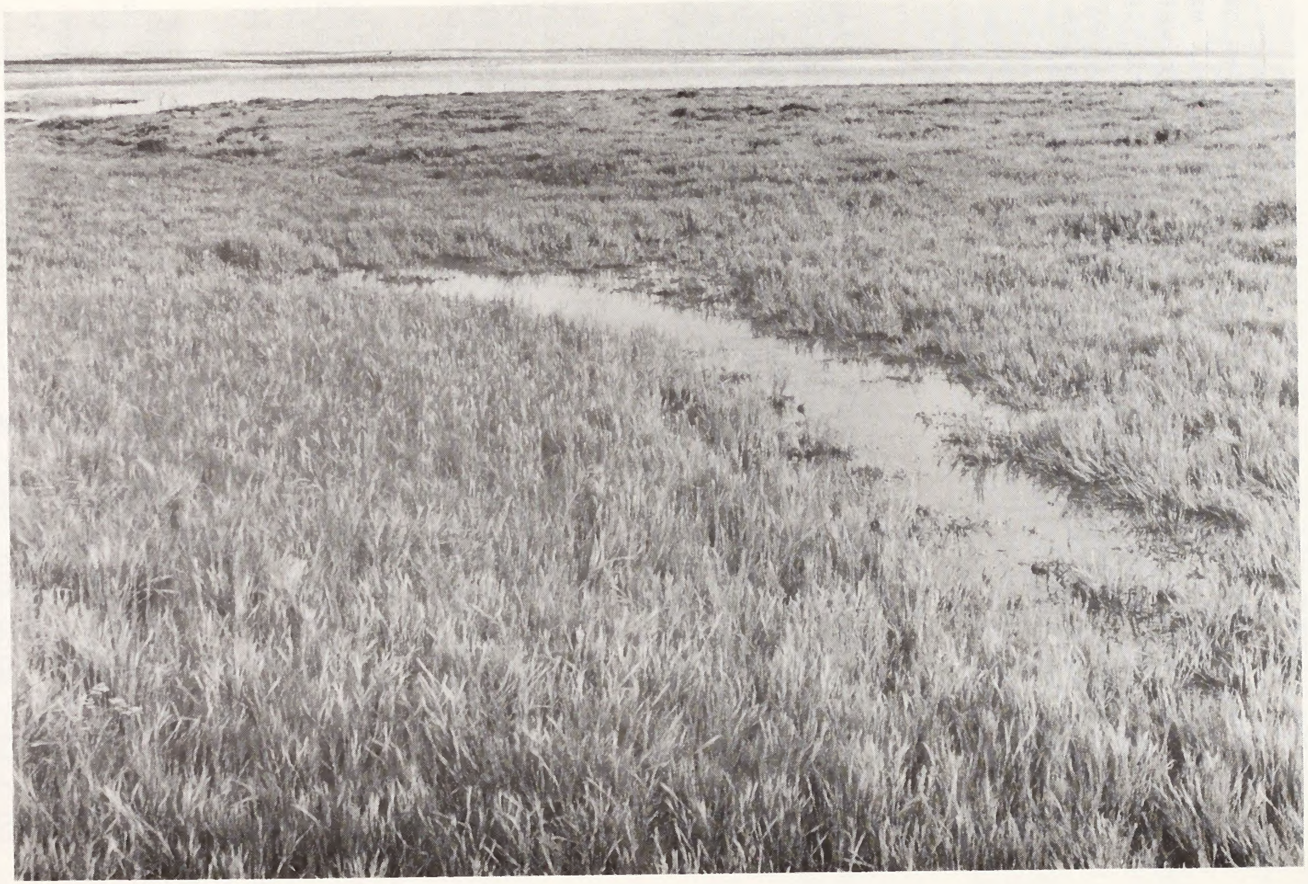
The aquatic wildlife habitat consists mainly of playas and lakes, which are high in salt content. There are 48 species of aquatic wildlife in the Study Area; 36 birds, 11 amphibians, and one fish. There are no known aquatic mammals and although several invertebrate species are present, very little is known about them. For a complete list of aquatic wildlife species, see Appendix B-2.

The only species on the U. S. Rare and Endangered Species List is the snowy plover which is classified as Status Undetermined. The State of New Mexico also has a list which identifies one species; Cyprinodon sp., an undescribed pupfish found in the Study Area, which is classified as endangered.

Part of the Study Area provides critical nesting habitat for the snowy plover. This habitat consists of barren alkali flats adjacent to shallow brackish ponds. Because this habitat is not abundant in the area, the distribution of the snowy plover is limited.

Clare Cranston of USGS indicates that Cyprinodon sp. is found in the brine lake which contains Nash Well along the Jal Highway. Also, BLM personnel collected a specimen of Cyprinodon sp. from the spring water entering Laguna Grande de la Sal. This spring-like area is rather small in size (3 to 5 feet wide and 30-35 yards in length, see Photo II-8). Dr. James Sublett of Eastern New Mexico University indicated that this species is similar to the Red River Pupfish Cyprinodon rubrofluviatilis. Cyprinodon sp. is also found in the Pecos River below Malaga Bend and in a salt spring near Loving, New Mexico. Most of the Cyprinodon sp. feed primarily on algae, but may also feed on other species of vegetation and occasionally on small flies.

PHOTO II-8 Habitat of Cyprinodon sp.



The Study Area provides critical nesting habitat for American avocet and the black neck stilt. The American avocet breeds sparingly and irregularly in the State, depending largely upon upland lake water conditions. The nesting site of the avocet is usually on sloping ground near ponds or lakes. Several avocets were observed around some of the lakes on the Jal Highway in early June 1975. No nests were found but their behavior indicated that the avocets were probably nesting. The black neck stilt nests a few inches above ground near alkali lakes.

Other species of shore birds and waterfowl are found in the Study Area at various times of the year and utilize the lakes and playas during migration or for a wintering area. Observations made in preparing this report indicate that waterfowl use of lakes in the area is inversely proportional to the chloride content in the lakes. That is, the saltiest lakes and ponds have the least waterfowl. Only 3 waterfowl were observed on ponds directly receiving effluent from a potash refinery, while 50-100 waterfowl were observed per lake on the lakes and ponds which are not receiving direct refinery effluent and which therefore have a lower chloride content.

Because of the high salinity of the lakes, they may not support a food supply for waterfowl. At this time, it is not determined whether the lakes are used for resting or for a feeding area by waterfowl. However, significant numbers of several waterfowl species are found on the lakes during the winter. During April of 1975, several Wilson's phalaropes were observed feeding on one of the natural lakes on the Jal Highway. At this time, an abundance of fairy shrimp (Branchinecta gigas, Lynch) were observed in this particular lake, and it is suspected that the phalaropes were feeding on this species of shrimp. This species is not a true brineshrimp, but is called a fairy shrimp and feeds primarily on single cell algae. In addition, these lakes appear to be potential habitat for the brine shrimp Artemia salinis, which is found in all continents and in the U. S. is best known from Great Salt Lake, Utah. This species tolerates salinities from saturation to 3 percent salt water. In Great Salt Lake, Artemia salina disappear in the fall when water temperatures drop below 6°C. None of these brine shrimp were observed in the study area.

Dr. Sublette is under contract with the New Mexico Game and Fish Department to inventory smaller fish species and water quality in the Pecos River from the Texas-New Mexico state line upstream to Las Vegas, New Mexico. His sampling method (a minnow seine) will provide information primarily on minnows and not the deep water dwellers such as those that might be found in Red Bluff Reservoir.

Dr. Sublette indicated that the report for this study will not be completed until August 1975. The preliminary examination of the inventory data from the Pecos River indicates that there are no endangered or threatened species. These data also indicate that a species composition change occurs in the Pecos River at Roswell.

Several species of amphibians inhabit the Study Area, however, it is not known to what extent they utilize the lakes.

b. Terrestrial Wildlife

The Study Area provided habitat for 168 species of terrestrial wildlife; 42 mammals, 94 birds, and 31 reptiles. Invertebrates are present but very little is known about these life forms. See Appendix B-3 for a complete list of Terrestrial Wildlife species.

None of the mammals or reptiles found in the Study Area appear on the State or Federal Rare and Endangered Species lists. Of the birds inhabiting the study area, eight are on the federal list and one is on the state list. The southern bald eagle and the peregrine falcon, both classified as Endangered on the federal list, probably migrate through the Study Area in winter.

The prairie falcon and the lesser prairie chicken are both classified as threatened on the federal list. The prairie falcon may winter in the area. The lesser prairie chicken does not inhabit the area, but part of the Study Area has been identified as a potential lesser prairie chicken habitat. Transplanting these birds has not been successful in the past. Preservation of the present habitat in areas of known prairie chicken distribution appears to be the key to maintaining their population.

There are four Status Undetermined birds on the federal list in the Study Area. They are the mountain plover, long-billed curlew, ferruginous hawk, and the burrowing owl. Part of the important breeding area of the mountain plover is in Lea County in areas of short grass with open plains, mesas and ridges which have a gravelly surface. The long-billed curlew is found in the Study Area during migration, and may possibly winter in the area.

The population of the ferruginous hawk has dwindled over the past several years. Indiscriminate shooting and a reduced food supply have been the main reasons for their decline (Ligon, 1961). Formerly, one of their most important food supplies was prairie dogs. As a result of the past massive poisoning of prairie dogs, the food supply for this species has been drastically reduced. Ferruginous hawks are generally only found in the Study Area during the winter.

Burrowing owls are found in the Study Area year-long. They were once more abundant when the population of prairie dogs was also much higher. The burrowing owl will use the burrows of kangaroo rats and badgers for nesting and protection.

McCown's longspur, classified as Endangered on the New Mexico list, is found in the Study Area during the late fall and winter. Ligon (1961, p. 305) reports that there are no nesting records of McCown's longspur for the State.

The major game mammals within the Study Area are antelope and mule deer. There is only a small, scattered population of these species, and the Study Area is considered as marginal habitat for deer and antelope. Mule deer are found in and around Nash Draw, which provides better cover than usually available in the area, because of the more rugged terrain. White-tailed deer have been reported in the area in the past; however, no recent sightings have been recorded. Most of the mammals found in the Study Area are rodents. The most abundant species are spotted ground squirrels, ord kangaroo rats, and grasshopper mice. A study was initiated to compare the relative abundance and species composition of rodents around three refinery sites compared to a control area in a similar soil type.

The data did not clearly indicate that there is a difference in rodent population levels between areas and the control areas. The reasons for this could be as follows: (1) There is no real difference, (2) The sample size was too small (1000 trap nights total), (3) Trapping was done around only 3 of the 7 refineries.

The results from the areas around the refineries indicated a decrease in the rodent population at IMC and Kerr-McGee and an increase at AMAX (Table II-66). The rodent population at AMAX was 2.5 times greater in the refinery area than in the control area.

The AMAX and IMC data indicated that spotted ground squirrels were the most abundant species in the refinery areas. The ord kangaroo rat was the most abundant species in the control areas of AMAX and IMC.

At Kerr-McGee, the small rodents such as the grasshopper mouse and deer mouse were the most abundant. These species usually do not burrow as deeply as the larger species, as evidenced by the shallow soil type near Kerr-McGee. This shallow type soil also appears to support a lesser population of rodents than the deeper soils.

The following mammalian predators are found in the Study Area: coyote, bobcat, kit fox and gray fox. These species are found year-long with the coyote being the most abundant. Rodents are their primary source of food.

The Study Area also provides habitat for several predatory birds which live off the rodent population. Year-round resident raptors include the great horned owl, red-tailed hawk, Harris' hawk, and the golden eagle. The great horned owl is one of the most widely distributed birds of the state. It is one of the earliest birds to nest and often chooses to nest in deserted hawk or raven nests in hackberry trees or large yuccas. However, their preferred nesting sites are pockets or crevices in rock cliffs or canyon walls. (Ligon, 1961)

Swainson's hawks nest in the Study Area, utilizing open country where trees are scarce. Their nests are found in such trees as cottonwood, hackberry, mesquite or any other tree (Ligon, 1961, pg. 66). The red-tailed hawk may also utilize part of the Study Area for nesting purposes. Generally this species will choose larger trees, such as cottonwoods along water courses or in canyons (Ligon, 1961, p. 65). The Study Area encompasses some of the principal nesting sites in hackberry, native chinaberry trees, cottonwoods, tree-sized mesquite and taller bunches of squawbush (Ligon, 1961, p. 71). The Study Area is also within the year-round range of the golden eagle. Conversations with various people who are familiar with the area, indicate that a small population of golden eagles has been observed in the Study Area during the winter months.

Some bird species where observed in close proximity to the refineries. However, very few bird nests were observed nearer than approximately one-quarter mile from a refinery site, even though nesting sites were apparently available.

The major game bird species within the study area are scaled quail and mourning dove. These two species are well distributed over the area and support the bulk of the upland hunting opportunities. According to New Mexico Department Game and Fish personnel, the quail and doves utilize some of the natural lakes for drinking water.

TABLE II, 66

RESULTS OF RODENT TRAPPING IN THE VICINITY OF THREE POTASH REFINERIES

	AMAX		KERMAC		IMC		TOTAL	
	Affected Area 200 Trap Nights	Control Area 200 Trap Nights	Affected Area 150 Trap Nights	Control Area 150 Trap Nights	Affected Area 150 Trap Nights	Control Area 150 Trap Nights	Affected Area 500 Trap Nights	Control Area 500 Trap Nights
Spotted Ground Squirrel	13	0	0	1	5	2	18	3
Grasshopper Mouse	4	0	4	3	1	6	9	9
Ord Kangaroo Rat	5	8	0	0	3	7	8	15
Deer Mouse	3	1	2	4	0	5	5	10
S. Plains Woodrat	0	1	0	0	0	1	0	2
Silky Pocket Mouse	0	0	0	0	0	1	0	1
13 Lined Ground Squirrel	0	0	0	1	0	0	0	1
	25	10	6	9	9	22	40	41

C. Ecological Interrelationships

The ecological balance which once existed in the Study Area was upset when livestock grazing was introduced into the area in the late 1800's. The vegetation close to water was overgrazed by livestock, and vegetative seeds and plant remnants from one area were disseminated into other areas. This resulted in a decrease in forage species and an increase in some other brush species. Soil erosion occurred, principally by wind, as the land was stripped of its protective cover by grazing.

The introduction of the potash industry in the mid 1920's again altered the ecological balance within the area. On the site-specific areas of the individual refineries, existing vegetative communities were affected in varying degrees by foreign particulates and effluent resulting from potash production. Vegetation was depleted, thus exposing areas to the forces of erosion. Salt-adapted vegetative species became established with animal compositions and habitat becoming affected.

The Study Area is located in a transitional zone between the grasslands biome and the hot desert (Chihuahuan Desert), but is most typical of the grassland biome. The precipitation received is used by plants and animals or is lost from the area through transpiration by plants and animals, evaporated back into the atmosphere or percolated to underground aquifers. Vegetative cover is comprised of mesquite, bush muhly, dropseed, plain bristle grass, gramas, three awn grasses, fourwing salt bush, creosote, catclaw and numerous annual forbs. Vegetation on the deeper, sandy soils is predominantly tall and mid-grasses, mesquite, shinnery oak and sand sage. The more shallow soils have short and mid-grasses, mesquite, creosote and broom snakeweed as some of the dominant vegetation. Where taller vegetation has attained a significant soil surface canopy, perennial plants may be prevented from normal growth. Numerous forbs are evident where sufficient precipitation is received. A few annuals or remnant perennial species may be growing on harsh areas (often scoured caliche) between dunes.

Because of their extensive root systems, large vegetation, such as mesquite, consume tremendous amounts of water to the detriment of other plant species. This tremendous competition for soil water coupled with the prevalent high evaporation rates of the unshaded soil surfaces, virtually eliminates perennial grass plants from becoming established. As a result, the barren dry soil surfaces are subject to varying degrees of wind erosion.

Precipitation on these barren areas is utilized by brush and annual forbs or quickly evaporated. Annual forbs generally occur in these barren areas during periods of above average precipitation. A great amount of water is lost through transpiration by vegetation with deep tap roots as compared to perennial grasses and forbs with root zones of less than three feet.

In an ecosystem complimented by vegetation, solar energy is absorbed by the plants and converted to chemical energy. Much of this solar energy is utilized by the plants to transfer soil moisture containing nutrients and minerals from the soil at a few feet depth up into the above ground portion of the plant (stems, leaves, etc.) for growth and reproduction of the plants.

The nutrients are translocated to the various parts of the plant, incorporated into the plant biomass and eventually return to the soil in the form of leaves, twigs and other plant parts that are shed. The bulk of this material falls directly beneath the individual plants. This process results in a more or less depleted nutrient regime away from the plants in the open areas, and a soil enriched by organic matter and nutrients beneath the plants. As the plant, or portions of the plant die, they fall to the ground and as the root systems die, the associated energy is transferred to microorganisms feeding on the dead vegetation or to the insects which obtain their energy and nutrient needs from the dead vegetation. Only specific microorganisms and insects are capable of this energy transfer.

Many animals such as insectivorous birds, bats, snakes, lizards and other animals obtain their energy from feeding on those insects. Herbivores obtain their energy and nutrients from the living parts of the plants, such as seeds, which are utilized by livestock, rodents and birds. Those herbivores living on the live materials and those organisms adapted to living on dead portions of the plants are subject to predation by carnivores. Hawks, falcons and coyotes are a few of these animals.

Nutrient and energy cycles based on plant associations dominated by a few plant species are very narrow. The number of plant and animals species through the energy transfer levels become narrow and limited also. Within the potash Study Area this is especially true and any alteration in vegetation or water supply will have profound effects throughout the whole energy and nutrient chain.

Many of the animals found in the Study Area depend upon the production of seeds and/or green vegetation for foods. In years of limited precipitation, vegetation is depleted or absent, causing those dependent animal species to decline and thus causing a decline in predator species. The influence of the potash industry also introduces similar effects on small areas of vegetation. It becomes depleted, sparse, and/or absent, thus creating the same conditions as exist under lack of moisture. This causes changes in the ecological balance site-specifically.

The most important factors influencing animals are sources of food, water, nesting and protective concealment for brood raising. The effects of potash particulates and effluent in altering the vegetative communities in the vicinity of refinery sites affects all of these factors negatively.

Rodent populations are cyclic and are dependent upon a seasonal food supply. Their food source consists largely of dry seeds, insects and green vegetation. Factors such as limited rainfall and depletion of vegetation will affect the food supply of these rodents. Any detrimental vegetative effects will introduce a decline in the rodent population.

There is an abundance of lizards and snakes in the Study Area. The majority of the species identified within the Study Area are common throughout Southeastern New Mexico and are not threatened by extinction. Food supply is the most important factor influencing the reptile population. Their primary food supply consists of spiders, insects, rodents and other small animals that live in or near the surface of the ground. Again limited precipitation or other factors which influence vegetation and cause fluctuations in vegetation will affect the food supply of lizards and snakes.

The Study Area is a portion of a larger area known to be one of the most important wintering concentration areas for birds of prey. The density of birds and the duration of their stay is largely dependent upon two factors: (1) the number of suitable perching areas (large brush, windmills, etc.) from which they can observe the area and (2) the density and availability of prey species.

Raptors are limited by lack of desireable nesting sites and food supply within the Study Area. The large trees necessary for raptor nesting and perching are scarce, generally being limited to Hackberry groves. The powerlines present throughout the Study Area do serve as an alternate nesting source.

Predatory birds are subject to extreme density fluctuation depending upon fluctuations in prey species. Alteration of environment through changes in water or vegetative cover will alter prey species availability and cause corresponding fluctuations in predator numbers.

Many of the upland birds are limited to certain areas which provide nesting and feeding sites. They are in many cases ground nesting and have specific vegetative requirements. These birds are restricted to a seasonal food and water supply, requiring green vegetation in the spring and dry seeds in the winter. The food supply and vitamin levels essential for reproduction are reduced because of the limited amount of precipitation. The birds and nests are also subject to high mortality through predation because of limited nesting site selection caused by the lack of proper vegetation.

A specific example is the scaled quail which is the most abundant game bird found in the Study Area. They are most abundant in areas of alternating brushy plants and grass cover. The population is extremely cyclic and in periods of limited spring precipitation, quail populations decline because few green forbs and grasses are produced. These grasses produce vitamin A which stimulates quail reproduction and if it is insufficient, quail do not nest. Insect populations are also dependent upon proper precipitation and vegetation and a decrease in insect numbers will also impact quail reproduction.

Shore birds make use of the existing water bodies at infrequent intervals. Partly this is because there are no major fresh water impoundments within the Study Area. The few stock reservoirs are occasionally utilized but during droughts and most springs and early summers the majority of these are dry and not usable. Shoreline habitat for these birds is very limited within the Study Area.

Waterfowl, like shorebirds, may or may not occur in significant numbers within the Study Area. The lack of major fresh water impoundments and the availability of only a few stock water reservoirs restricts the expansion of waterfowl into the area. It appears that nesting does not occur within the Study Area. Limited use is made of water areas by waterfowl at infrequent periods since resting and feeding areas containing aquatic vegetation are generally lacking.

Big game animals in the Study Area are limited by a small food and water supply and also by lack of sufficient protective vegetative cover. They are not abundant and generally are concentrated close to water during the summer months. The lack of sufficient moisture has reduced vegetation necessary for food and cover. Limited precipitation in the area also limits the water supply for game animals.

Predators such as coyote, badger, kit fox, skunk, etc. also are affected by changes in vegetation and water supply. Their numbers will fluctuate with those of their prey.

D. Human Environment

The Carlsbad potash Study Area consists of some 970,000 acres of semi-arid lands. The impression is one of broad open spaces complimented by the generally clear blue western skies. (See photo II-9). The relief within this area is attributed to dune fields and collapse features typical of Karst topography. Variety of color provided by vegetation is very slight during most of the year, because of the subtle shading of the transitional vegetation. The exception to this condition occurs in the spring, following a particularly wet season when numerous wild flowers bloom in shades of yellow, blue, purple and orange. The greatest variation in color is provided by the reddish sand dunes and the salty lagunas dotting the area. The relatively slight variations in elevation and the generally low growing vegetation provide frequent opportunities for vistas in excess of 10 miles.

1. Aesthetics and Recreation

This natural landscape is overlain by an intricate web of evidences of human cultural influence on the western scene. Ranching is one of the characteristically western activities which is evident in the area. The ranching operations in the area are basically cattle operations with the cattle grazing on leased federal range and few ranch headquarters buildings scattered throughout the area.

Another human cultural influence on the landscape is oil and gas development. Oil and gas wells are located throughout the area, with the highest concentrations along the northern and eastern edges of the Study Area. These operations are characterized by the presence of drilling rigs and the traditional pump jacks, sometimes called horses heads, dotting the area (see Photo II-10).

A third human cultural influence on the landscape is mining, specifically potash mining. This activity is evidenced by the presence of traditional head frames located over vertical shafts and surrounded by tailings piles. An additional, and frequently the most obvious, evidence of the mining activity in this area is the presence of the potash refineries. The potash refineries have a very "busy" appearance with their conveyor lines, numerous buildings, salt piles and emissions issuing forth from their exhaust stacks. (See Photo II-11)

PHOTO II-9 Potash Study Area

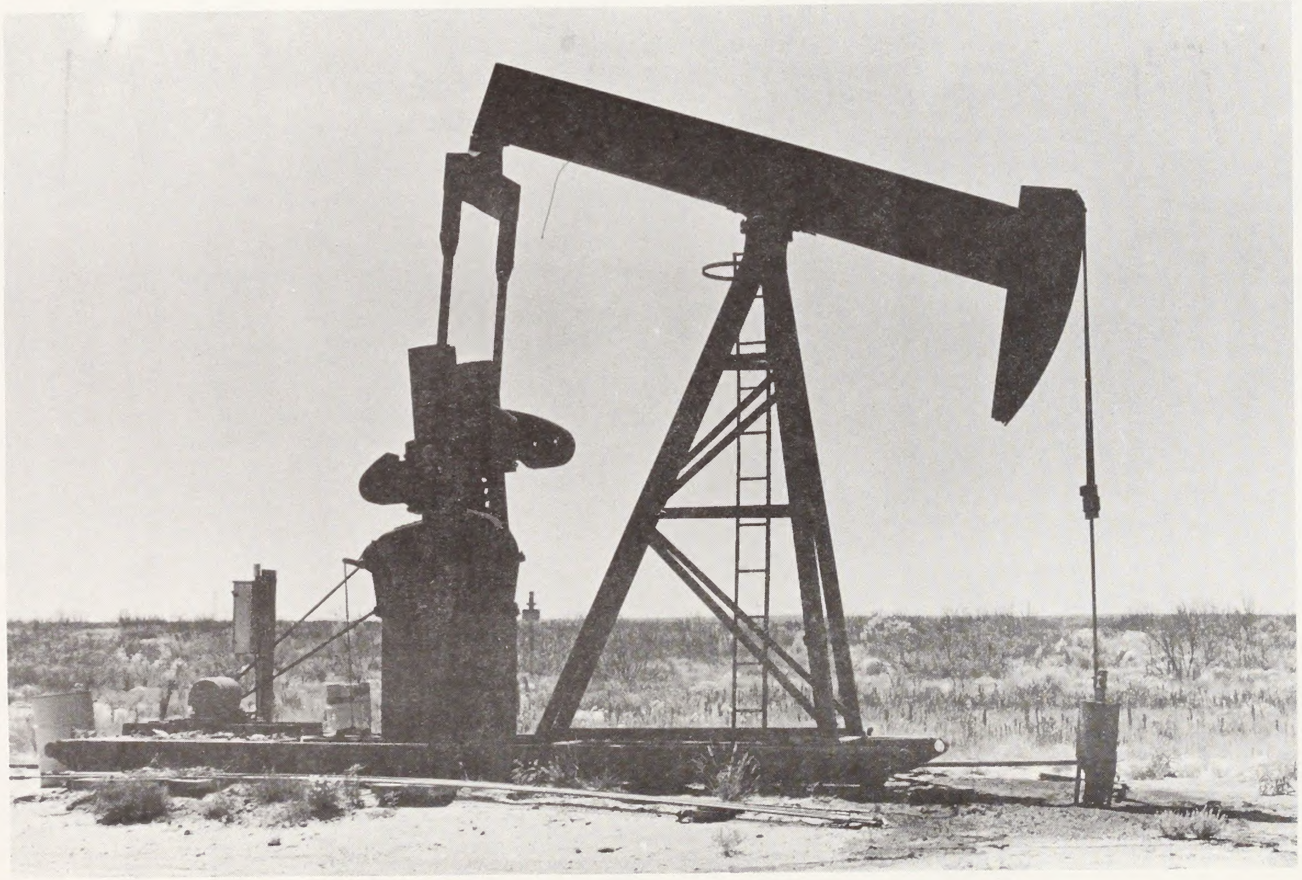


PHOTO II-10 Pump Jack

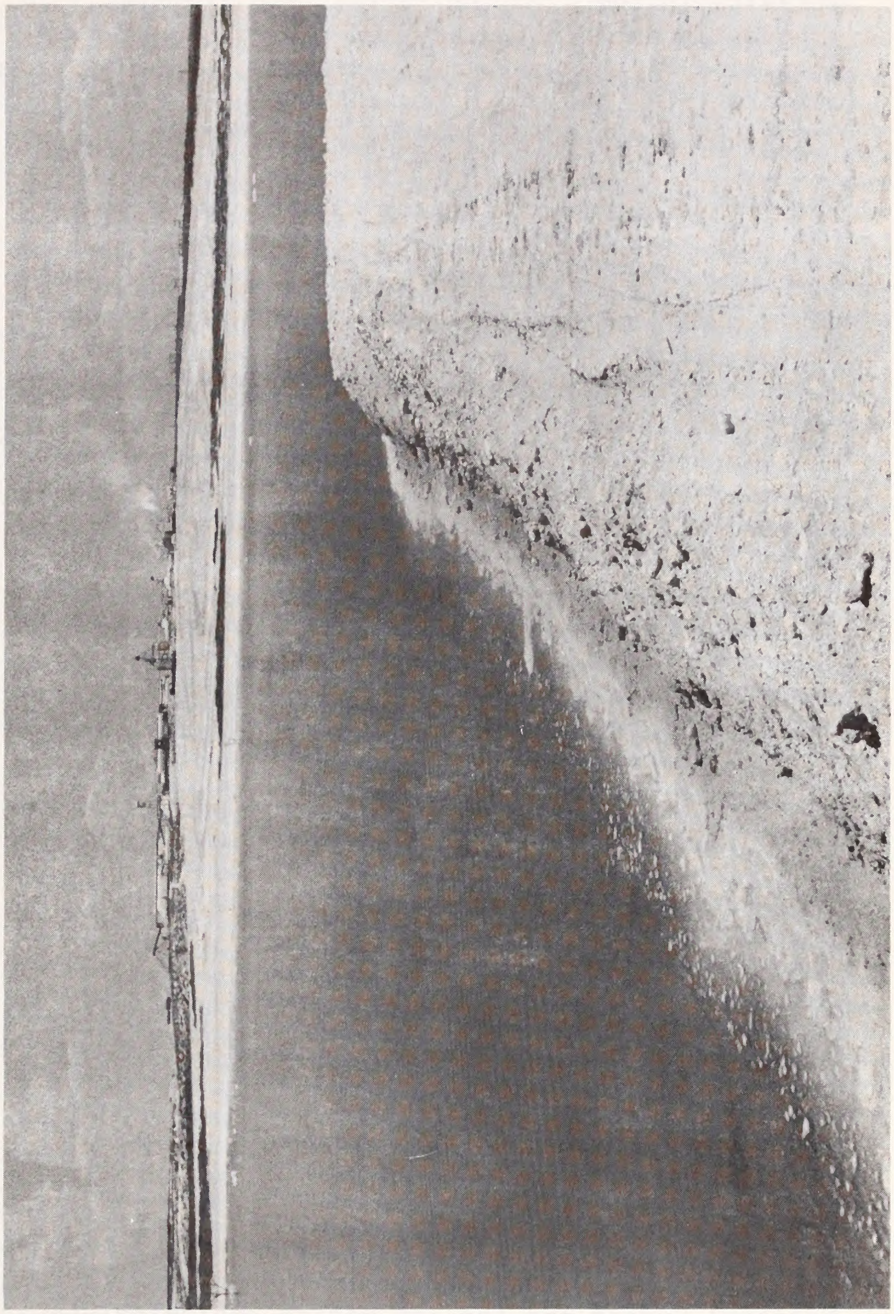


PHOTO II-11 Potash Refinery (Duval Chemical Corporation)

These stack emissions add another dimension to the of human activity in the area, specifically a brownish haze, which frequently darkens the sky and blocks out views of the mountains to the west. This haze is visible from as far away as the Guadalupe Mountains on the west, the Texas border on the east and south, and Artesia on the north.

All three of these activities, ranching, oil and gas development, and potash mining are linked together by a maze of powerlines, pipelines, railroads and roadways. The scars from these support facilities are visible from most locations within the Study Area and several of them in combination are visible from all of the major travel routes crossing the area. (See Photos II-12, II-13, and II-14.)

An evaluation of the overall scenic quality of the Study Area was undertaken on April 8, 1975. Utilizing the Bureau of Land Management's quality evaluation system ratings were made from sixteen vantage points along the paved highways dissecting the study area. The overall rating for the Study Area was near the top of the "C" class range (see Table II-67 and Map II-9.) Three of the quality ratings for specific vantage points rated in the "B" class and one in the "A" class with the rest of ratings covering the entire range of the "C" class. The one "A" class area was the Salt Lake as viewed from N. M. 31 just south of the IMC plant. The three "B" class areas were Gatuna Canyon, Maroon Cliffs and Nash Draw. All four of these higher rated areas achieved their ratings because of the color variation provided by reddish dunes and cliffs with the added bonus of water in the salt lake area (see photo II-15).

The major travel routes crossing the study area consist of both U. S. and New Mexico paved highways. For the highway numbers and locations see Map II-9, p. 266. In addition to use by local residents, these highways are used by interstate travelers. See Table II-68 for average daily traffic figures on these highways. A portion of the travelers on these highways are vacation or recreation oriented. Existing recreation facilities near the area are Carlsbad Caverns National Park, Guadalupe Mountains National Park, Lincoln National Forest and the New Mexico Zoological-Botanical State Park. Visitor use figures for these areas in terms of visitor days for 1974 are Carlsbad Caverns, 671,721; Lincoln National Forest, 91,600; Guadalupe Mountains National Park, 39,294; and Zoological-Botanical State Park, 57,231.

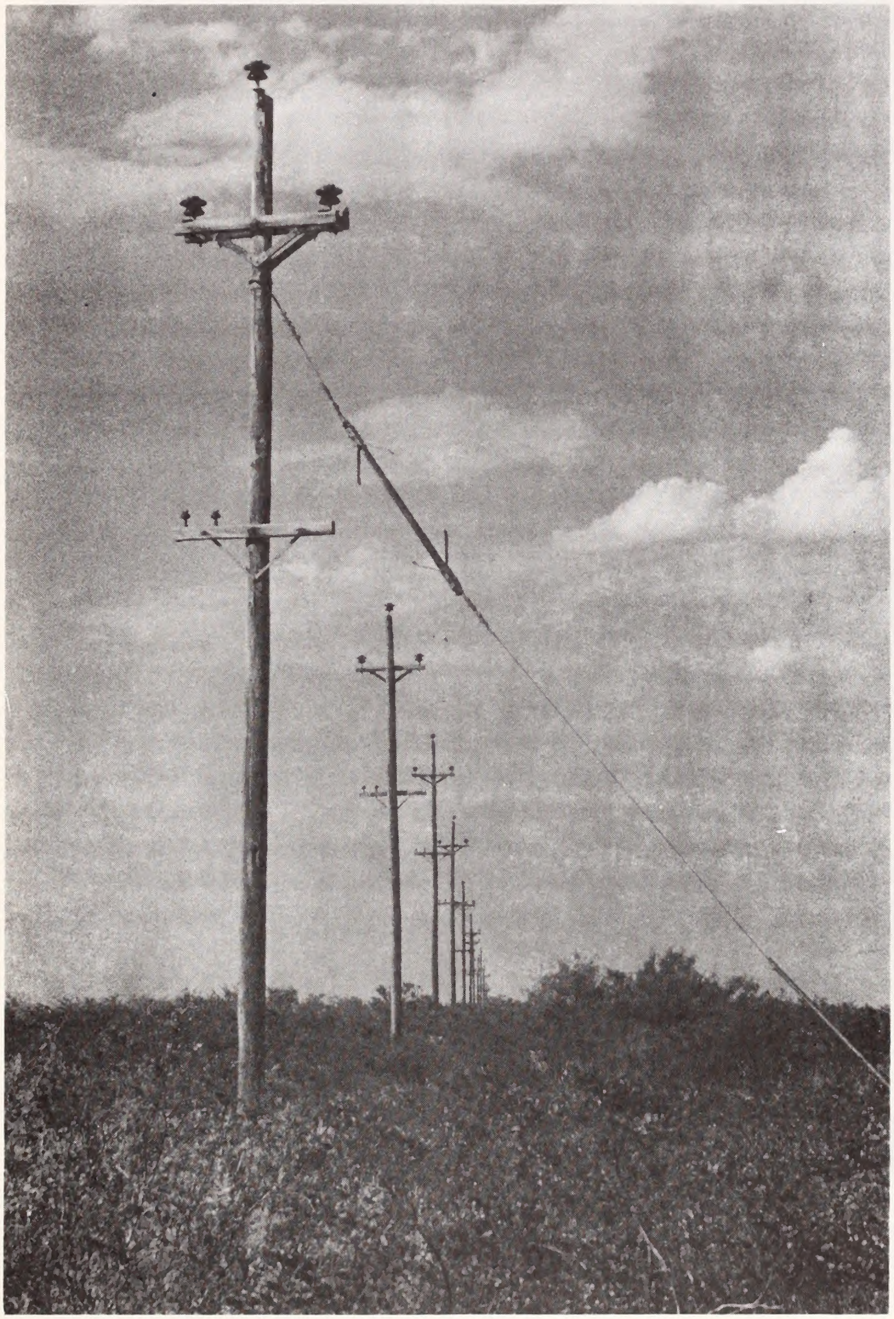


PHOTO II-12 Powerline in Potash Study Area

PHOTO II-13 Pipeline in Potash Study Area

PHOTO II-14 Railroad and Roadway in Potash Study Area

TABLE II-67

1. Date
4-8-75

2. Rater
C. GODFREY

3. State
NEW MEXICO (030)

4. District
ROSWELL (060)

5. Plan Unit
CARLSBAD KPA

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

QUALITY EVALUATION SCORESHEET

6. Recreation Activity
SCENERY

CLASS	SCORE RANGE
	7
A	15-24
B	10-14
C	1-9

8. KEY FACTORS

9. RATING AREA		LAND FORM	COLOR	WATER	VEGETATION	UNIQUENESS	INTRUSIONS			11. TOTAL SCORE	12. CLASS	13. REMARKS
		10. POINT MAXIMUM										
NO. (a)	NAME (b)	4	4	4	4	6	2			24		
001	MIMOSA RIDGE	1	2	1	2	1	1			8	C	
002	PCA	1	2	2	2	1	1			9	C	
003	GATUNA CANYON	2	4	1	2	1	1			11	B	
004	LUSK RANCH	1	1	1	1	1	1			6	C	
005	OIL FIELDS	1	2	1	1	1	-4			2	C	
006	CAPROCK	2	2	1	2	1	1			9	C	
007	QUERECHO PLAINS	1	1	1	2	1	1			7	C	
008	HALFWAY	1	2	1	2	1	1			8	C	
009	MAROON CLIFFS	2	4	1	2	1	1			11	B	
010	LOCO HILLS	1	2	1	2	1	1			8	C	
011	NASH DRAW	2	4	1	2	1	1			11	B	
012	SALT LAKE	1	4	4	4	1	1			15	A	
013	NASH WELL	2	2	4	2	1	-4			7	C	
014	JAMES RANCH	1	2	1	2	1	1			8	C	
015	LOS MEDAÑOS	1	1	1	2	1	1			7	C	
016	BERRY RANCH	1	1	1	1	1	1			6	C	
*017	OVERALL RATING									8	C	TOTAL AREA

(Instructions on reverse)

Form 6110-10 (August 1972)

May 14, 1975

TABLE II-67 cont.

GENERAL INSTRUCTIONS

District Office prepares and maintains one (1) copy in file for each recreation activity or subactivity within a planning or inventory unit. (See BLM Manual 6111)

SPECIFIC INSTRUCTIONS

(Items not shown are self-explanatory)

Item

6 *Recreation Activity* – Enter major recreation and, if appropriate, the subactivity.

7 *Class & Score Range* – Enter range of scores for *each* class from quality evaluation chart.

8 *Key Factors* – Enter key factors from quality evaluation chart.

9 *Rating Area*
(a) *Number* – Enter numerical identifier.
(b) *Name* – Enter name which generally describes area.

10 *Point Maximum* – Enter maximum points for *each* key factor from quality evaluation chart.

11 *Total Score* – Enter summation of points given *each* key factor.

12 *Class* – Enter class within which total score falls. (See Item 7, above)

13 *Remarks* – Use this column to describe any unique or different situation.

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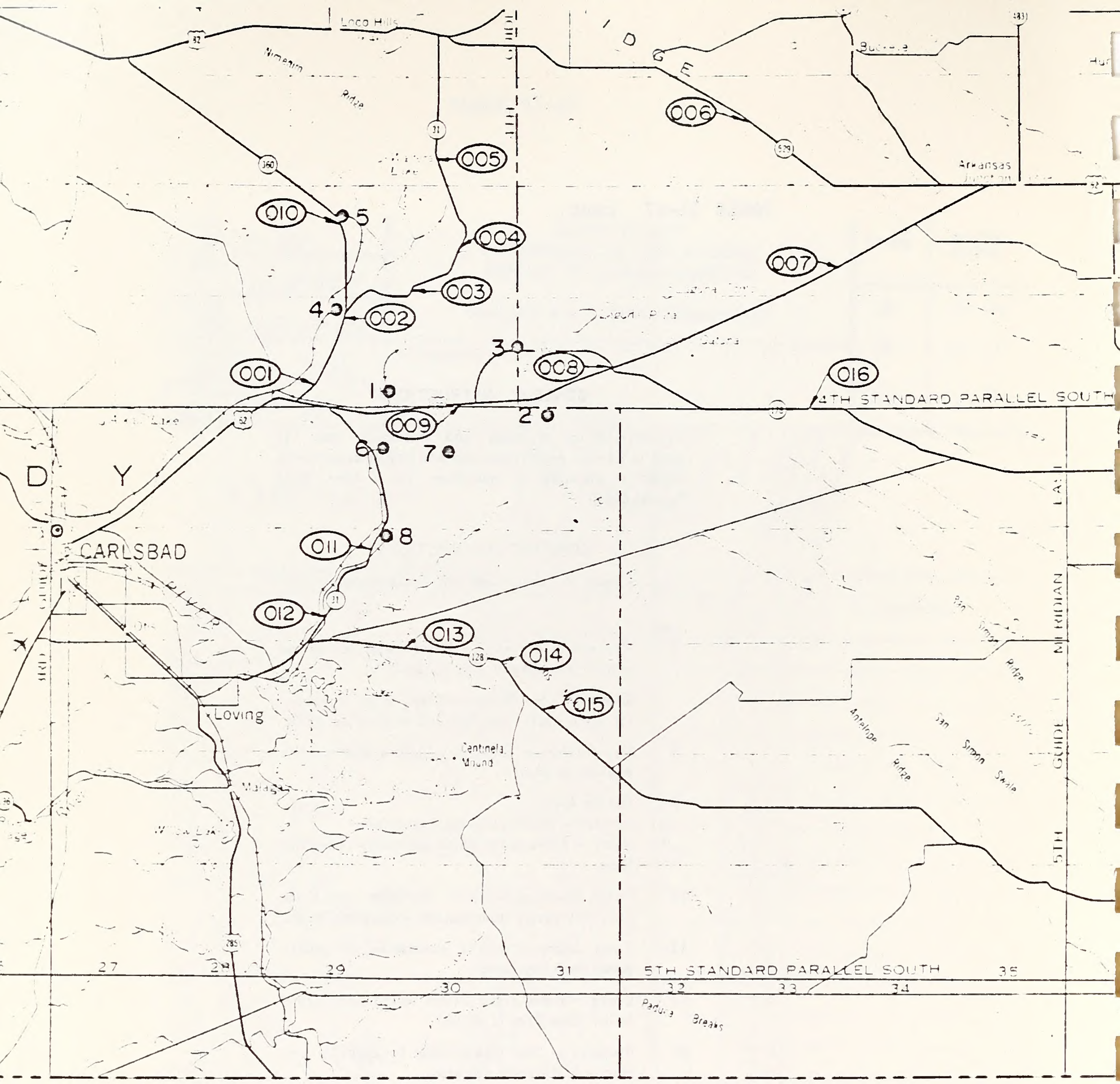


Map II-9 Quality Evaluation Map

1 - DUVAL REFINERY
2 - KERR MCGEE REFINERY
3 - NATIONAL REFINERY
4 - POTASH CO. OF AMERICA REFINERY
5 - AMAX CHEMICAL REFINERY
6 - MISSISSIPPI POTASH REFINERY
7 - MISSISSIPPI POTASH NEW REFINERY SITE
8 - INTERNATIONAL MINERALS CORP. REFINERY

PHOTO II-13 Maroon Cliffs

TABLE II-68

AVERAGE DAILY TRAFFIC FIGURES

Highway	Avg. Daily Traffic	Approximate % of ADT Out of State Veh.
U.S. 62/180	2,135	58
U.S. 82	1,345	21
N.M. 31	536	12
N.M. 128	245	Fig. not available
N.M. 176	650	Fig. not available
N.M. 285	1,946	17
N.M. 360	186	10
N.M. 529	853	Fig. not available

After: New Mexico Traffic Survey,
New Mexico State Highway
Dept. Santa Fe, 1973

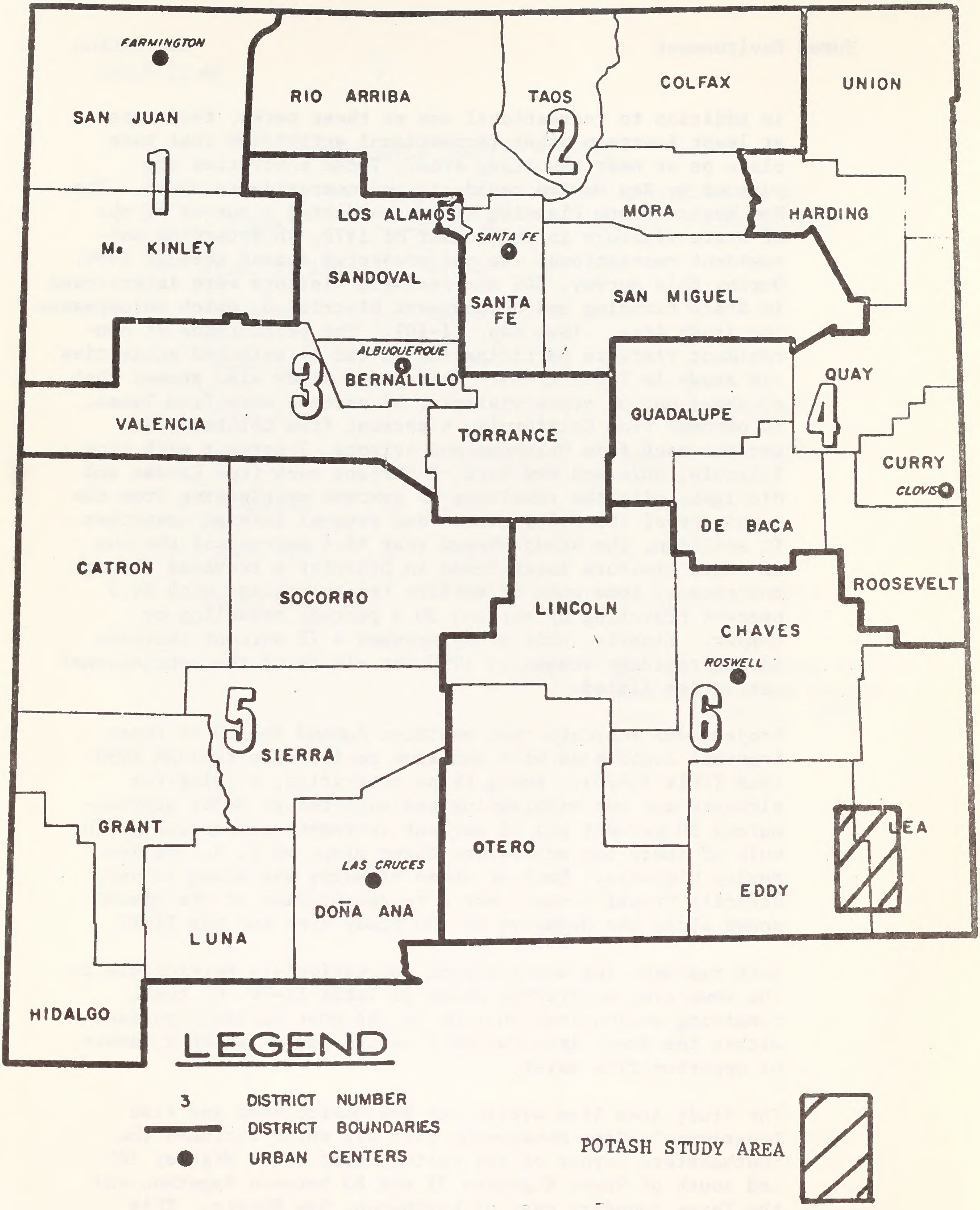
In addition to recreational use at these parks, there are at least fourteen other recreational activities that take place on or near the Study Area. These activities are pursued by New Mexico residents and nonresidents alike. The New Mexico State Planning Office conducted a survey of out of state visitors in the summer of 1972, to determine non-resident recreational use and projected demand through 1990. During this survey, 546 non-resident visitors were interviewed in State Planning and Development District 6, which encompasses the Study Area. (See Map II-10). The percentages of non-resident visitors participating in the 14 selected activities are shown in Table II-69. This state study also showed that of these out of state visitors, 32 percent were from Texas, 10 percent from California, 6 percent from Colorado, 5 percent each from Oklahoma and Arizona, 3 percent each from Illinois, Ohio and New York, 2 percent each from Kansas and Michigan, with the remaining 29 percent originating from the remainder of the fifty states and several foreign countries. In addition, the study showed that 98.4 percent of the out of state visitors interviewed in District 6 traveled through the area by some mode of surface transportation with 66.5 percent traveling by car and 20.3 percent traveling by camper. Finally, this study assumed a 72 percent increase in non-resident demand by 1990 for all 14 of the recreational activities listed.

Projections indicate that resident demand for 10 of these fourteen activities will continue to increase through 1990. (See Table II-70). Among these activities, driving for pleasure and car sightseeing are expected to enjoy approximately 50 percent and 52 percent increases respectively. The bulk of these two activities takes place on U. S. and New Mexico highways. Each of these highways has along it very definite visual zones. For a representation of the visual zones along the highways in the study area see Map II-11.

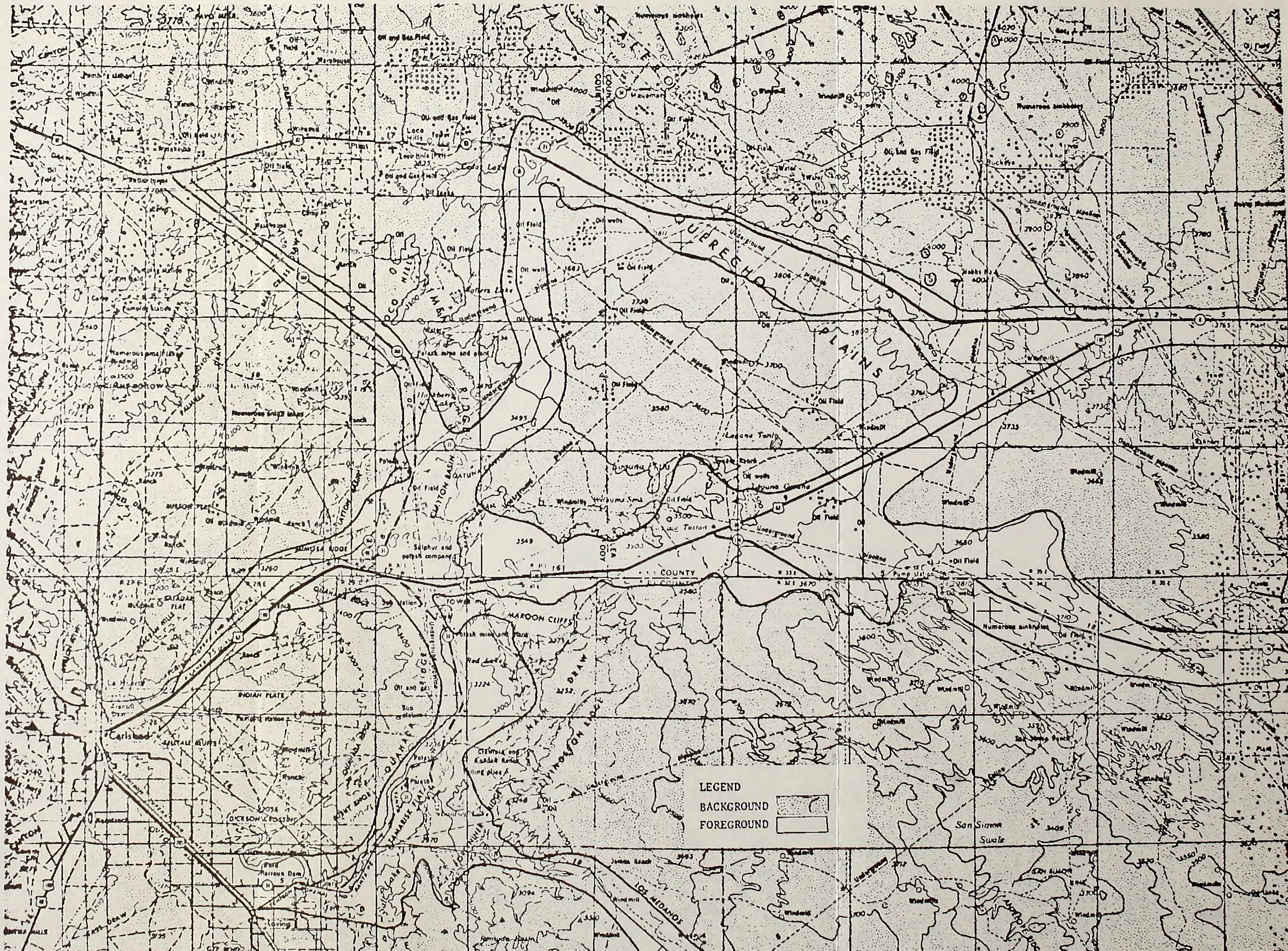
Both resident and non-resident recreationists participate in the remaining activities shown in Table II-70. Of these remaining activities, hunting is the most actively pursued within the Study Area, as well as the one of which a number of opportunities exist.

The Study Area lies within the New Mexico Game and Fish Department's Game Management Unit 61, which includes the Southeastern corner of New Mexico, east of US Highway 285 and south of State Highways 31 and 83 between Hagerman and the Texas boundary east of Lovington, New Mexico. This management unit is the designation for a mule deer management area.

MAP II-10



NEW MEXICO PLANNING AND DEVELOPMENT DISTRICTS



MAP II-11 Visual Zone Areas

TABLE II-69

Percentage of Out of State Visitors Participating in Area Six By Activity

Driving for Pleasure	60.1
Picnicking	36.1
Walking for Pleasure	34.9
Fishing	14.0
Car Sightseeing	83.0
Hunting	0.9
Horseback Riding	19.0
Hiking	19.0
Lake Swimming	11.1
Camping (Campground)	38.0
Boating	4.1
Camping (Wilderness)	82.9
Outdoor Gatherings	10.1
Jeep & Trail Biking	6.0

After: Out of State Visitor
Recreation Demand Patterns In
New Mexico, State Planning Office,
Santa Fe 1973

N = 546

TABLE II-70

NEW MEXICO RESIDENT OUTDOOR RECREATION DEMAND BY ACTIVITY FOR DISTRICT 6

Activity	1975 *	1990 *	Approximate % Increase/Decrease
Driving for Pleasure	1,455,660	2,177,160	+ 50
Picnicking	520,931	788,189	+ 51
Walking for Pleasure	2,071,107	3,313,770	+ 60
Fishing	851,901	1,122,960	+ 32
Car Sightseeing	546,135	831,075	+ 52
Hunting	362,620	361,705	- .3
Horseback Riding	787,083	1,201,335	+ 53
Hiking	339,732	610,968	+ 80
Lake Swimming	226,640	226,065	- .3
Camping (Campground)	149,484	279,678	+ 87
Boating	296,557	530,427	+ 79
Camping (Wilderness)	114,225	113,937	- .2
Outdoor Gatherings	103,347	105,086	+ 2
Jeep & Trail Biking	146,862	146,484	- .3

* All figures are in terms of activity occasions based on the formula.

D = P x T x R
D = DEMAND
P = POPULATION IN THE DISTRICT
T = PERCENT OF PEOPLE WHO DESIRED TO PARTICIPATE
R = NUMBER OF TIMES PARTICIPANTS ENGAGE IN EACH ACTIVITY

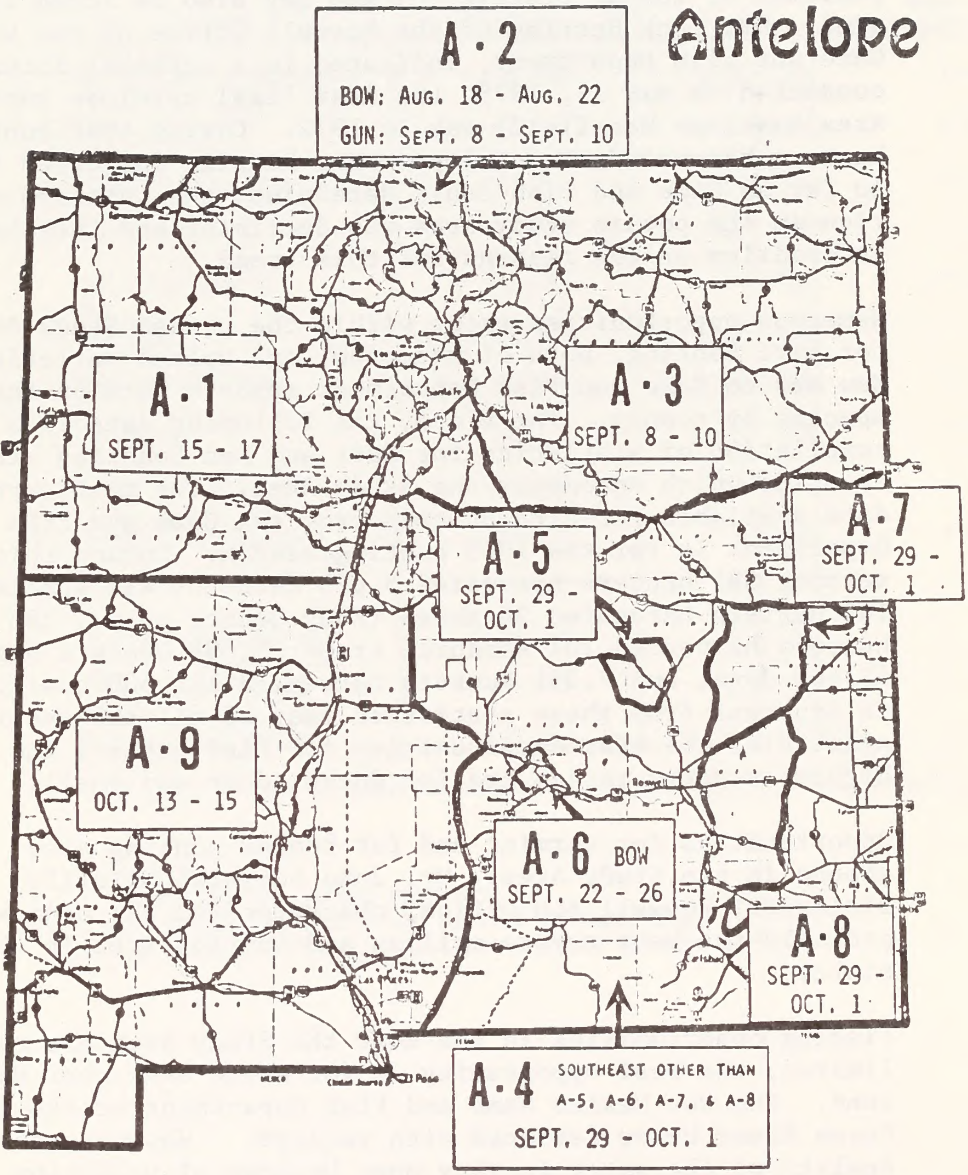
After: Outdoor Recreation, a
comprehensive plan for New Mexico
N. M. State Planning Office
Santa Fe 1971

In 1974, according to Game and Fish Department statistics, 517 hunters harvested 60 mule deer in this unit. Other game animals which can be found in the Study Area are antelope, ducks, geese, sandhill cranes, dove and quail. An occasional pheasant or lesser prairie chicken may also be found in the area. Mr. Jack Herring of the Roswell Office of the State Game and Fish Department, indicated in a personal interview, conducted on may 19, 1975, the last legal antelope hunt in Area A-4 (see Map II-12) was in 1972. During that hunt, 82 hunters harvested 61 antelope. Mr. Herring indicated that so far as Game and Fish could determine, the antelope population in the potash study area was declining and they had no information on the reasons for this trend.

Numerous opportunities exist within the potash Study Area for bird hunting, both of waterfowl and upland varieties. New Mexico Game and Fish Department reports data on these species by county. Therefore, the following data is a compilation of statistics for Eddy and Lea Counties -the two counties which encompass the Study Area. The most current data available for bird hunting from the Game and Fish Department is for the 1973 hunting season. During this season, 581 hunters harvested 5,625 ducks of all species, 148 hunters harvested 98 geese (Eddy County only), 183 hunters harvested 204 sandhill crane, 5,498 hunters harvested 63,661 dove, and 7,331 hunters harvested 141,500 quail. It is apparent from these statistics that of all the species available, the best opportunities for bird hunters and the highest success ratios are for ducks, dove and quail.

Opportunities for varmint and fur bearer hunting also abound in the Study Area. Mr. John Schwarz, Wildlife Biologist, Roswell BLM Office, characterized the area as probably the best coyote calling and hunting area in the state.

Fishing opportunities in and near the Study Area are extremely limited, the best opportumity is for white bass near Malaga Bend. The New Mexico Game and Fish Department stocks the Pecos River below Carlsbad with walleye. However, the quality of the water is very poor because of pollution from Carlsbad and irrigation runoff, and therefore suitable fish habitat is a problem. Limited opportunities for large mouth bass, channel catfish and blue gill also exist. (Moody, 1974 personal interview.)



MAP II-12 Antelope Hunt Areas

From: New Mexico Hunting Proclamation, 1973

Opportunities for other types of recreational pursuits exist in the vicinity of the Study Area but not within its boundaries. A quantification of these opportunities is shown in Table II-71.

2. Transportation Safety

Several paved U. S. and N. M. highways cross the Potash Study Area. (See Map II-10, p. 230.) At two locations along N. M. 31 signs warning of potential hazard from subsiding road surface are posted. These two areas are in the vicinity of the Mississippi Chemical Co. and AMAX refineries, where second mining has taken place under the highway. Although during periods of high stack emissions from the Duval and IMC refineries, visibility along portions of U. S. 62/180 and N. M. 31 is noticeably reduced, no accidents have been related to stack emissions. However, the report of an accident which occurred on January 3, 1974, indicated that the driver was looking at a potash mine instead of the highway when his vehicle ran off the pavement and rolled over.

TABLE II-71

RECREATION FACILITIES IN VICINITY OF POTASH STUDY AREA*

Type of Facility	Eddy County Public	Eddy County Private	Lee County Public	Lee County Private	Total
Picnic Units	152	110	141	-	403
Camp Units	68	-	-	-	68
Trails	28	-	-	-	28
Swimming Beaches	1	-	-	-	1
Lakes	25	-	-	-	25
Fishing Waters	-	1	-	2	3
Shooting Preserves	-	2	-	-	2
Riding Stables	-	1	-	-	1
Boating	-	2	-	1	3

After: Outdoor recreation, a
comprehensive plan for New Mexico
State Planning Office, 1971

* Note: These figures do not include opportunities for pursuit of activities at undeveloped sites.

3. Archaeology and Paleontology

That part of southeastern New Mexico utilized by the potash industry is also an area containing paleontological, archaeological and historical resources. Little research has been done in this area by professional archaeologists, paleontologists and historians for a variety of reasons. Interest has tended to focus on areas to the north and west in the case of all three disciplines. Archaeological neglect is partly the result of interest in the more spectacular ruins of the San Juan District (i.e., Chaco Canyon and Mesa Verde) and the possibilities of tieing these ruins to still extant Indian peoples such as the Pueblos and the Navajos. These areas were felt to be the major cultural centers and southeastern New Mexico was regarded as a cultural backwater or "marginal area."

In addition, this area was not settled extensively until quite recently. Spanish history is scanty and Anglo settlements did not reach any great size until the 1880's. Grazing was the major industry until the discovery and development of gas and oil reserves and potash. The nature and extent of cultural resources was greatly underestimated and is only now beginning to be appreciated. Increased recreational use of the land is also resulting in further interest in cultural resources.

Recent work by both professional and amateur groups (Eastern New Mexico University, School of American Research, Lea County Archaeological Society, etc.) indicates that the cultural resources of southeastern New Mexico are of importance in terms of current research goals in the field of archaeology. Many questions concerning the relationship between environment and culture may be answered in this area because of the "marginal" nature of the environment and the cultures.

The only known paleontological research in the potash area involves the mammoth site salvaged by the Carlsbad Archaeological Society. A number of paleontological studies have been done west of the Pecos River by the University of Texas at El Paso, (Harris 1970) and these indicate the possibility of other sites east of the river.

Mera (1943), Lehmer (1948) and Jelinek (1958) are the three basic references on the archaeology of southeastern New Mexico. Mera's (1943:1) study was oriented primarily to pottery types in southeastern New Mexico and their relationship to ceramic types to the west. His outline of brownware creamics in southeastern New Mexico was the basic reference for a number of years, and he described the archaeology as follows (ibid.:3):

> East of the Pecos river many open campsites occur, all exhibiting considerable amounts of the same generalized type of brownware that is found elsewhere throughout the region. Occupational areas of this sort extend as far east as the second northsouth tier of counties in Texas, wherever a sand dune terrain exists.

Lehmer (1948) synthesized the archaeology of part of southeastern New Mexico and incorporated Mera's data to define what he termed the Jornada Branch of the Mogollon culture. This did not include the more easterly portions of southern New Mexico, but it did form the basis of classification of sites in that eastern portion. The base phase (Hueco) which developed out of the Archaic or hunting-gathering period was essentially a non-ceramic continuation of the Archaic. The Hueco Phase lasted until 900 A. D., and northern and southern variants of the Jornada Mogollon developed from it. These variants and their time frames are listed below:

	North	South
1200-1400 A.D.	San Andres	El Paso
1100-1200 A.D.	Three Rivers	Dona Ana
900-1100 A.D.	Capitan	Mesilla
?900 A.D.	Hueco	

(Lehmer 1948:89)

Pottery appears near the end of the San Andres and El Paso phases and is a brownware similar to that described by Mera (1943).

Jelinek (1958) conducted a survey of the Pecos River valley north of Roswell, and Schaafsma (1975) has made projections in the Carlsbad area based on this survey. Jelinek established four phases which compare favorably with those of Lehmer:

Middle Pecos III	1200-1350 A.D.
Middle Pecos II	1100-1200 A.D.
Middle Pecos I	950-1100 A.D.
Pre-Ceramic	pre 950 A.D.

(Jelinek 1958)

Based on the work described above, and on field reconnaissance in Lea and Eddy Counties, Corley (1965) proposed extending the boundaries of the Jornada Mogollon, as described by Lehmer (1948) to include the rest of southeastern New Mexico and part of west Texas (see Map II-13). He termed this the eastern extension of the Jornada Mogollon and the phases and their time frames are listed below:

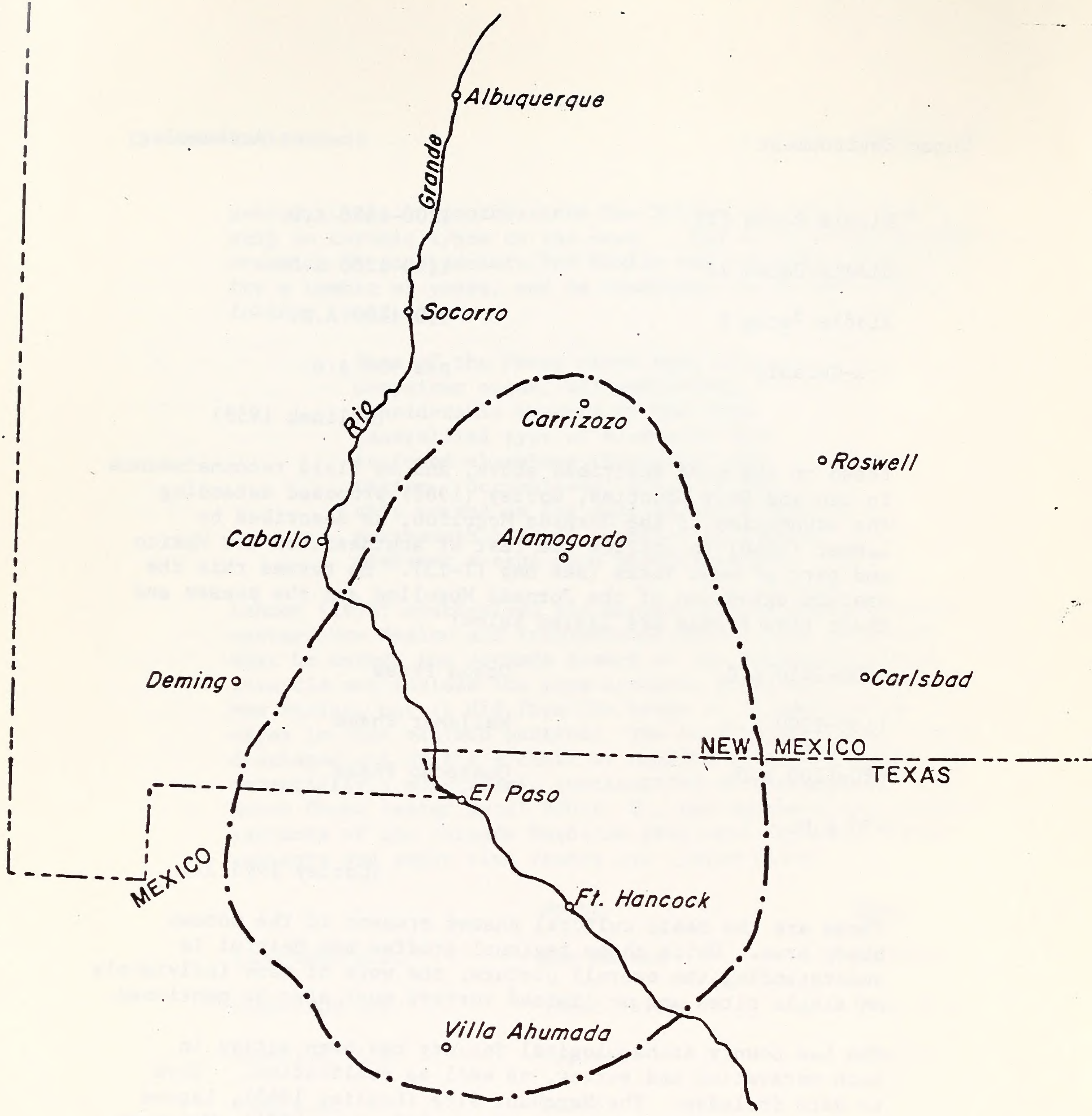
1300-1450 A.D.	Ochoa Phase
1100-1300 A.D.	Maljamar Phase
950-1100 A.D.	Querecho Phase
950 A.D.	

(Corley 1965:32)

These are the basic cultural phases present in the potash Study Area. While these regional studies are helpful in understanding the overall picture, the work of many individuals on single sites and on limited surveys must also be mentioned.

The Lea County Archaeological Society has been active in both excavation and survey, as well as publication. Work to date includes: The Merchant Site (Leslie, 1965), Laguna Plata Site (Lea County Archaeological Society 1971), Monument Springs (Leslie 1968), Boot Hill (Corley and Leslie 1960), and Rattlesnake Draw (Smith, et. al. 1966). The Society is also making an intensive inventory of cultural resources in Lea County for the Bureau of Land Management.

M. B. Collins (1968) reported on work carried out at Andrews Lake in Texas, and his summary of work in southeastern New Mexico and West Texas reflects work done in the potash basin.



MAP II 13 *Physiographic diagram of the Jornada Area showing the extent of the Jornada Branch.*

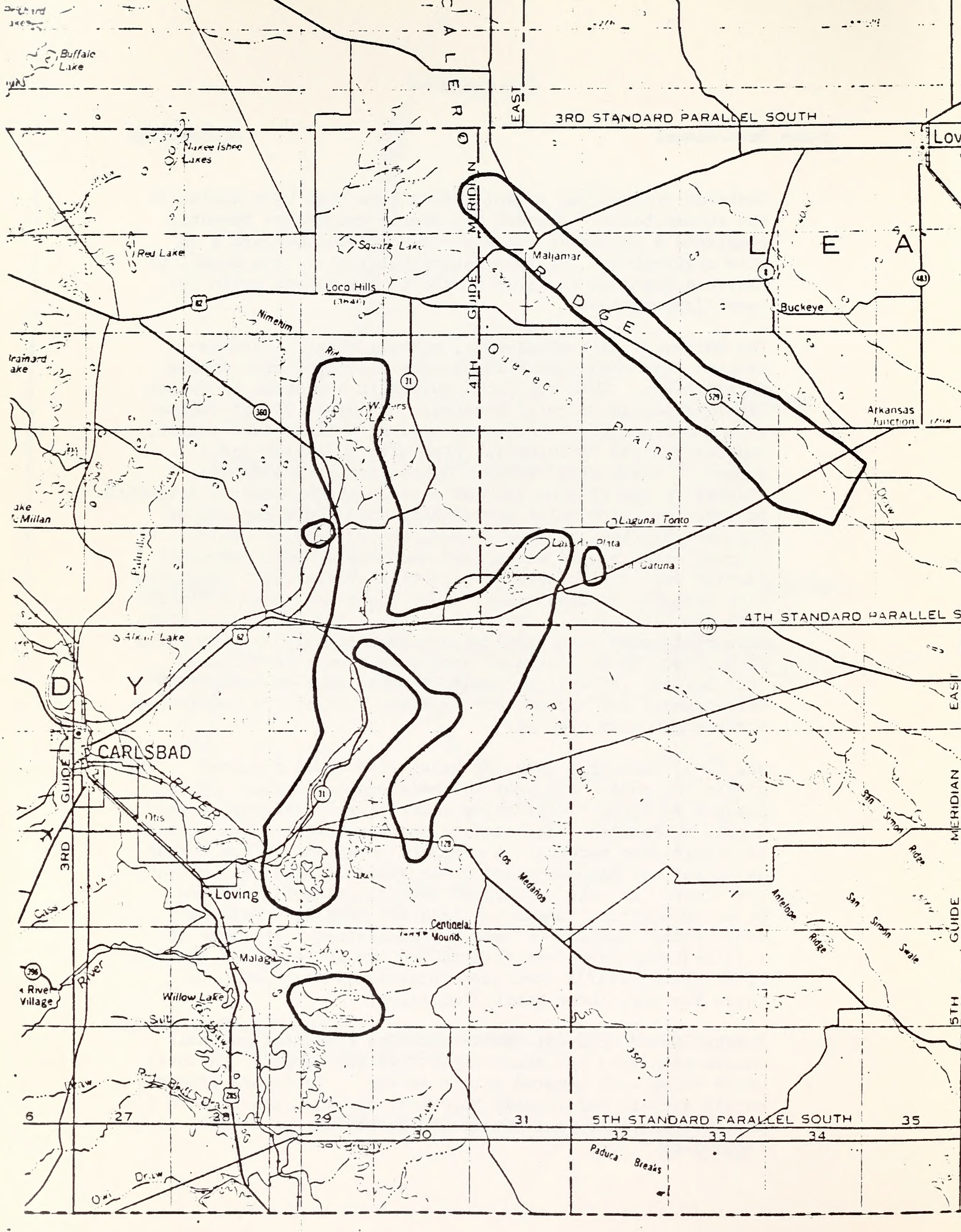
AFTER LEHMER 1948:10

Contract archaeology organizations have also been active in the potash basin. Eastern New Mexico University recently completed a survey of two and one-half sections and a 30 mile right-of-way for Mississippi Chemical. The School of American Research has also worked in the potash basin for Duval Corporation.

The Bureau of Land Management, Roswell District Archaeologist also conducted a three week reconnaissance in the potash basin. This was not a survey in the sense of either sampling design or total coverage. A number of informants with knowledge of the area, as well as a literature search, indicated areas of potential high site densities and a number of these were viewed. Other similar areas were checked to see if a pattern of site location could be discerned. In addition, each existing refinery with the exception of Mississippi Chemical, was checked on foot and by vehicle for terrain favorable to sites, and sections of such favorable terrain were spot checked for cultural resources. Investigation revealed archaeological sites on or near each refinery, with the exception of National Potash. All identified sites near refineries have been damaged by both surface disturbing activities and by increased access. It must be stressed that not all cultural values in the vicinity of refineries were identified, nor may any refinery vicinity be considered archaeologically cleared.

Map II-14 indicates areas of known site concentrations within the potash basin of southeastern New Mexico. Sites damaged by surface disturbing activities (pipelines, powerlines, refineries, etc.) and by increased access are present in significant numbers. A complete inventory of the potash basin has not been done and other areas of high site density are certain to exist. All of the following figures are based on a minimal amount of data and must be considered projections, subject to future modification. A number of rights-of-way have been cleared and two and one-half sections of the Maroon Cliffs have been intensively surveyed. Of these surveys, three merit discussion.

Eastern New Mexico University surveyed a two and one-half square mile area for Mississippi Chemical Company. A total of 38 sites were located by the survey. These are predominately Archaic and Jornada Mogollon, and are located both in the lowlands below the Maroon Cliffs and on the cliffs themselves.



MAP II-14 —— *Area of high site densities*

A proposed pipeline right-of-way was surveyed by Eastern New Mexico University (ENMU). A total of 21 sites were encountered in the survey which was approximately 30 miles long and 50 feet wide. The sites were of an Archaic and Jornada Mogollon Character. The proposed pipeline partially follows an existing pipeline and a number of the 21 sites had been damaged by the installation and maintenance of the existing pipeline.

The third survey mentioned here was conducted by the School of American Research for Duval's new gas line. This short transect encountered no cultural materials directly within the right-of-way, although some were noted in the vicinity.

Schaafsma (1975) discusses the probability of encountering one site within a 50 foot transect, one mile long, assuming a site density of 12 per square mile. One strip in 10 would encounter a site. By these statistics, the ENMU survey described above should have encountered four sites. Twenty-one were found. From this, it appears that the site densities in this part of New Mexico may be higher than 12 per square mile.

Table II-72 lists those sites which have been recorded and are on the Bureau of Land Managemnt Archaeological Inventory. Other sites are known within the potash basin, but have not yet been inventoried, and are not included in the chart. A number of the sites have been damaged noticeably by surface disturbing activities. The statistics derived from this chart should be considered a sample, subject to later modification as the data base increases.

In terms of time period, the greatest number of sites fall within 950-1400 A.D. (Jornada Mogollon). The Archaic (500 B.C.-950 A.D.) has the next greatest number of sites. Paleo-Indian and Historic sites are least well represented. This is in partial agreement with Schaafsma's (1975) estimates for the area. He had estimated that Archaic sites would be most common, with the other 3 time periods less well represented. This would be expected largely because of the greater time span of the Archaic and the seasonal nature of the subsistence pattern. The reasons for the greater actual number of Jornada Mogollon sites is unknown and may actually be a result of reporting biases.

Campsites form the largest type of site and this category has not been broken down any further. Sites included

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
17	19s/34e	camp	no	Archaic?	ridge top	yes	NR Maroon Cliffs
18	19s/34e	camp	yes	Eastern Jornada	dunes	yes	Possible strata NR Maroon Cliffs
23	18s/39e	mortar-holes camp	yes	Eastern Jornada to 1400	ridge near lake	no	
24	20s/30e	camp-hearth	Chupadero b/w	Eastern Jornada - 1200	rim of ridge		
25	20s/30e	camp-hearth	El Paso Polychrome	1200-1400	flat land	road	
26	20s/30e	mortar holes	no	?	edge of lake dunes/hills	yes	near plant
27	18s/30e	pithouses?	yes	Eastern Jornada	dunes near lake		pithouses
31	22s/34e	pithouses	SEE MERCHANT SITE REPORT				
34	21s/31e	camp	yes	Eastern Jornada 100-1100	dunes	pipeline & highway	poor
35	19s/30e	midden/camp/ pithouses?	late types	Archaic, Eastern Jornada	ridgetop	pipeline	
36	20s/30e	camp	yes	Eastern Jornada	sand	powerline	
37	19s/34e	camp	Brownwares	Eastern Jornada 1000-1200	dunes	road	
38	18s/34e	quarry-camp	no	Paleo-Eastern Jornada	hill w/outcrop		
41	19s/34e	pithouses?	yes	Paleo-Archaic Eastern Jornada-Historic	hill		
42	21s/31e	rockshelter	no	?	sandstone cliff		
43	20s/32e	camp	?	Archaic-Eastern Jornada	dunes		
45	20s/29e	camp	El Paso Brown	Eastern Jornada	ridge above lake	yes	
51	21s/29e	hearths	El Paso Brown Chupadero b/w	Eastern Jornada	dunes		
52	21s/29e	camp	El Paso Brown	Eastern Jornada	junction 2 draws		
74	19s/34e	camp	Roswell Brown	Archaic-Eastern Jornada (1000-1300)			
80	19s/34e	camp	Brownware, Mimbres b/w, Broad line R/Te, Chupadero b/w	Eastern Jornada 1000-1200	rim of ridge		

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
87	20s/33e	dune camp	Brownware	Eastern Jornada 1000-1100	dune		
88	18s/34e	camp	Brownware	Eastern Jornada (Querecho)	dune on ridge		
93	21s/30e	midden	yes	Eastern Jornada	hill near cliff	some	NR Maroon Cliffs
94	21s/30e	camp-pithouses?	El Paso Brown	Eastern Jornada	hillside	pipeline	NR Maroon Cliffs
95	21s/30e	camp-pithouses?	El Paso Brown	Eastern Jornada (Querecho)	below cliff	road	NR Maroon Cliffs
96	21s/30e	camp-pithouses?	Glaze A	late Eastern Jornada	caliche hill		NR Maroon Cliffs
97	21s/30e	mortars	?	?	ss outcrop	road/pipeline	NR Maroon Cliffs
98	21s/30e	camp	no	Archaic	dune on cliff	pipeline	NR Maroon Cliffs
99	21s/30e	camp	no	Archaic-Eastern Jornada	sand		NR Maroon Cliffs
100	21s/30e	midden camp	no	?	hilltop		NR Maroon Cliffs
101	21s/30e	camp	Brownware	?	dune		NR Maroon Cliffs
107	20s/32e	midden, mortars rooms?	yes-late	Eastern Jornada-Apache 1200-1350	dunes on lake		NR (Laguna Plata)
108	19s/34e	camp	no	Paleo-Archaic	small hill below cap		
109	19s/34e	camp	no	Paleo-Archaic	below cap		
110	20s/32e	camp	yes	Archaic-Eastern Jornada	dune on lake		NR (Laguna Plata)
113	20s/32e	camp-midden	yes	Archaic-1500	knoll by lake	oil field	NR (Laguna Plata)
114	20s/32e	dune midden	Brownware & others	Archaic-1300	dune on lake		NR (Laguna Plata)
117	20s/32e	dune midden	yes	Archaic-1400	dune on lake	oil field	NR (Laguna Plata)
118	18s/34e	camp	no	?	below cap		
119	18s/34e	camp	Brownware, Mimbres b/w, Broadline R/TC	Archaic-Eastern Jornada (Hueco-Quercho)	deep sand below cap		
120	20s/32e	camp	Brownware	Archaic-Eastern	by lake		NR (Laguna Plata)
136	21s/31e	mortars	El Paso Brownware & Polychrome, Chupadero b/w	Archaic-Eastern Jornada Apache	sandstone shelf of ridge		
163	23s/29e	camp	yes	?	dune		

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
179	19s/34e	camp	Chupadero b/w, El Paso Brown, Roswell Brown	Eastern Jornada (H&Q) (Hueco-Querecho)	dune near lake	powerline	
184	18s/34e	camp	El Paso Brown	Eastern Jornada-1200	ridge	highway	
185	18s/33e	camp	SEE REPORT			yes	
186	21s/30e	camp	Brownware, El Paso Polychrome, Chupadero, b/w	Archaic-Eastern Jornada (1300)	hill below cliff		NR Maroon Cliffs
189	21s/30e	camp	El Paso Brown, Roswell Brown, Chupadero b/w	Archaic-Eastern Jornada (Querecho)	dunes		NR Maroon Cliffs
198	20s/33e	camp	Brownware	Archaic-Eastern Jornada (950-1000)	near lake		
219	20s/33e	camp	no	Archaic	near lake		
222	19s/34e	camp	no	Archaic	dunes		
223	19s/34e	camp	Brownware, red/br. Chupadero b/w	Eastern Jornada (Hueco-Maljamar)	dunes	pipeline	
225	22s/30e	camp	Chupadero b/w Brownware	Eastern Jornada	dunes-ridge		
227	22s/30e	camp	Brownware Chupadero b/w	Eastern Jornada	dunes-ridge		
251	21s/30e	camp	Roswell, Brown, Chupadero b/w	Eastern Jornada (Hueco-1200)	dune near wash		NR Maroon Cliffs
253	21s/31e	midden-rooms	r/br, Brownware Chupadero b/w, 3 rivers R/TC, El Paso Polychrome, Glaze A, Roswell corrugated	Eastern Jornada (Hueco-1350)	on ridge		
254	21s/31e	camp	no	Archaic	between wash and ridge		
255	21s/31e	camp-midden	Brownware, r/br, Chupadero b/w, 3 Rivers R/TC, Lincoln Br/r, El Paso Polychrome, Glaze A, Roswell corrugated, Ochoa Indented	Archaic-Eastern Jornada (1350)	ridge		

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
258	21s/30e	camp	no	?	mesa top		NR Maroon Cliffs
259	21s/31e	camp	no	?	low rise		
260	22s/30e	camp	El Paso Brown	Archaic-Eastern Jornada (Hueco)	ridge	pipeline	
265	21s/30e	camp	Brownware, Chupadero b/w	Eastern Jornada (Hueco)	ridge		NR Maroon Cliffs
266	21s/30e	camp	Brownware, r/br, Chupadero b/w	Eastern Jornada (1200)	ridge		NR Maroon Cliffs
267	19s/34e	camp	no	Paleo-Archaic	a round well		
268	19s/34e	camp	Roswell Brown corrugated, El Paso Brown, 3 Rivers R/TC, Chupadero b/w	Paleo-Eastern Jornada (1300)	ridge	pipeline	
269	21s/30e	camp	Brownware, Chupedro b/w	Eastern Jornada (1250)	dune ridge	2 pipelines	NR Maroon Cliffs
271	20s/33e	camp	Brownware, r/br, Chupedro b/w, El Paso Polychrome	Eastern Jornada (Hueco-Maljamar)	dune by lake		
273	20s/33e	camp	Brownware, Roswell Brown, corrugated, Chupadero b/w, 3 Rivers R/TC	Eastern Jornada (1300)	dune by lake		
308	23s/30e	camp	no	Archaic (Hueco) 950-1000	dune		
398	20s/29e	hearth	?	?	dune		
458	19s/32e	camp	Brownware	?	dune		
475	19s/34e	quarry	no	?	rock outcrop		
479	20s/29e	camp	no	?	blowout	road	
480	20s/29e	hearths	Brownware	?	alluvium		
481	20s/33e	hearth-camp	no	?	on lake		

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
482	20s/31e	hearth-camp	no	?	dune		
510	21s/30e	camp	br/r, Chupadero b/w Roswell corrugated, 3 Rivers R/TC	Eastern Jornada	ridge		NR Maroon Cliffs
513	21s/30e	camp	Brownware thru Glaze A	Eastern Jornada thru 1500	dune around lake		NR Maroon Cliffs
514	21s/30e	camp	Brownware, Chupadero b/w	Archaic, Eastern Jornada 1200	on cliff		NR Maroon Cliffs
515	21s/33e	camp	Chupadero b/w, Ochoa Indented	Archaic-Eastern Jornada (1400)	small mesa		NR Maroon Cliffs
516	21s/30e	camp	Brownware, Chupadero b/w El Paso & Ramos polychrome, 3 Rivers & Lincoln Br/r, Roswell Corrugated, Ochoa Indented	East Jornada all phases to 1500	dune		NR Maroon Cliffs
10012	21s/30e	camp	no	Archaic	valley bottom		NR Maroon Cliffs
10013	21s/30e	hearth	yes	Eastern Jornada	valley bottom		NR Maroon Cliffs
10014	21s/30e	camp	no	?	ridge		NR Maroon Cliffs
10015	20s/31e	camp	yes	Eastern Jornada	dune/ridge		
10016	20s/31e	camp	yes El Paso Brown, Chupadero b/w	Archaic-Eastern Jornada 1300AD	dunes		
10017	20s/32e	camp/hearth/ pithouses?	El Paso Brown, Jornada Brown, unid. B/W	Archaic-East Jornada	dune/playa		NR Laguna Plata
10018	20s/32e	chipping site	no	?	dune/playa		NR Laguna Plata
10019	20s/32e	camp	no	?	dune		NR Laguna Plata
10020	19s/32e	camp	yes - painted wares	Eastern Jornada (?)	dune		
10021	19s/32e	camp	El Paso Brown, others	Eastern Jornada	dune		
10022	19s/32e	camp	Brownwares	Eastern Jornada	dune		
10023	19s/32e	camp	no	?	dunes		
10024	19s/33e	camp	El Paso Brown	Eastern Jornada	dunes		

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
10025	19s/33e	camp	no	?	dune		
10026	19s/33e	camp	no	Archaic	dune		
10027	19s/33e	camp	reddish brown sherd	Eastern Jornada (?)	dune		
10028	19s/33e	camp	Brownware	Eastern Jornada (?)	dune		
10029	19s/33e	camp	yes	?	dune		
10030	18s/33e	chipping station	no	?	dune		
10031	18s/34e	camp	El Paso Brown	Eastern Jornada (?)	dune		
10032	18s/34e	hearths	El Paso Brown	Eastern Jornada	dune		
10033	21s/30e	camp	El Paso Brown, Jornada Brown	Eastern Jornada	ridge		NR Maroon Cliffs
10034	21s/30e	camp	no	Eastern Jornada (?)	ridge		NR Maroon Cliffs
10035	21s/30e	hearths	no	?	dune		NR Maroon Cliffs
10036	21s/30e	camp	yes	?	flat		NR Maroon Cliffs
10037	21s/30e	hearths	no	?	flat/dune (?)		NR Maroon Cliffs
10038	21s/30e	camp	Jornada Brown	Eastern Jornada	dune		NR Maroon Cliffs
10039	21s/30e	camp/hearths	El Paso Brown, Jornada Brown	Eastern Jornada	dune		NR Maroon Cliffs
10040	21s/30e	hearth	no	?	ridge		NR Maroon Cliffs
10041	21s/30e	camp/hearth	Jornada Brown	Eastern Jornada	ridge		NR Maroon Cliffs
10042	21s/30e	camp	no	?	dune		NR Maroon Cliffs
10043	21s/30e	camp	no	?	ridge		NR Maroon Cliffs
10044	21s/30e	camp/hearth/ pithouses?	yes	Eastern Jornada	dune/ridge		NR Maroon Cliffs
10045	21s/30e	camp	Jornada Brown	Eastern Jornada	ridge		NR Maroon Cliffs
10046	21s/30e	camp	yes	?	dune		NR Maroon Cliffs
10047	21s/30e	camp	El Paso Red on Brown	Eastern Jornada	dune		NR Maroon Cliffs
10048	21s/30e	hearth	no	?	ridge		NR Maroon Cliffs
10049	21s/30e	camp	Jornada Brown	Eastern Jornada	ridge	Pipeline	NR Maroon Cliffs
10050	21s/30e	hearth	yes	?	dune		NR Maroon Cliffs
10051	21s/30e	camp/pithouses (?)	El Paso Brown, Jornada Brown	Eastern Jornada	dune		NR Maroon Cliffs
10052	21s/30e	hearths	El Paso Brown, Jornada Brown	Eastern Jornada	dune		NR Maroon Cliffs

Chart II-72

PRELIMINARY ARCHAEOLOGICAL INVENTORY OF POTASH STUDY AREA

No.	Location	Type	Pottery	Time	Terrain	Damage	NR Importance/Comments
10053	21s/30e	camp	El Paso Brown, Jornada Brown	Eastern Jornada	dune		NR Maroon Cliffs
10054	21s/30e	camp	El Paso Brown Chupadero b/w	Eastern Jornada	dune		NR Maroon Cliffs
10056	21s/30e	hearth	yes	?	ridge		NR Maroon Cliffs
10057	21s/30e	camp	no	?	dune		NR Maroon Cliffs
10058	21s/30e	hearths/pithouses?	yes	?	ridge/hilltop		NR Maroon Cliffs
10060	21s/30e	hearths/pithouses?	Jornada Brown	Eastern Jornada	ridge/hilltop		NR Maroon Cliffs
10061	21s/30e	hearths/pithouses	no	?	hilltop		NR Maroon Cliffs
10062	21s/30e	hearths	yes	Archaic-Eastern Jornada	ridge		NR Maroon Cliffs
10063	21s/30e	hearths	yes	?	dune	Pipeline	NR Maroon Cliffs
10064	21s/30e	hearths	Jornada Br.	Eastern Jornada (?)	dune		NR Maroon Cliffs
10065	21s/30e	hearth/pithouses(?)	yes	Eastern Jornada (?)	dunes		NR Maroon Cliffs
10066	21s/30e	pithouses(?)	yes	Eastern Jornada (?)	dunes		NR Maroon Cliffs
10067	21s/30e	camp	no	?	ridge		NR Maroon Cliffs
10068	21s/30e	camp	yes	?	dune		NR Maroon Cliffs
10069	21s/30e	hearth	yes	?	flat		NR Maroon Cliffs
10070	21s/30e	camp	yes	?	dune		NR Maroon Cliffs

here may be multi-functional, seasonal, single use, etc. In many cases, further investigation and subsurface testing are needed for a more definitive classification. It should be noted that although architectural sites form only 3.6 percent of inventoried sites, Leslie and Runyan (Personal communication 1975) feel they are more common. Further testing will probably show that many sites classified as camps are in reality architectural sites.

Terrain is the last category which has been quantified. In some cases, sites are located in a combination of terrain situations and in those cases the site has been classified in terms of the most dominant. The prehistoric inhabitants of the potash basin favored those locations which involved dunes, playas, cliffs or combinations thereof. Sites near playas are often in a dune setting and form 26.5 percent of the sample. Dune locations alone formed 29.1 percent of all sites inventoried, and cliff situations formed 21.5 percent. It should be noted that sites have been found in other locations such a flats, hilltops, draws and cliff overhangs.

Site density within the potash basin has been calculated on the basis of data gathered by ENMU on the Mississippi Chemical survey. In addition, figures proposed by Schaafsma (1975) for the Carlsbad area are instructive. Schaafsma based his figures on projections from similar areas in New Mexico, and postulated a site density of 12 sites per square mile. Of these 12, 1 would be Paleo-Indian, 10 Archaic, and 1 Jornada Mogollon. Historic Indian sites would be less than 1 per square mile. The Mississippi Chemical survey recorded 38 sites within a two and one-half square mile area, or a density of 15.2 sites per square mile. Sites were broken down into ceramic versus nonceramic with a ratio of 25 to 13. This density compares favorably with that found in the Rio Grande area where the Cochiti Lake survey recorded a density of approximately 11-13 per square mile. The WESCO survey in the San Juan District encountered a density of 5 to 8 sites per square mile, while the Navajo Irrigation Project is running 5 to 7 sites per square mile. The only comparable survey in the Carlsbad area involves the proposed flood area of the Brantley Dam, which has a density of two sites per square mile. This area had been heavily farmed and it is assumed that a large number of sites had been destroyed prior to the survey. It appears that the site density within the potash basin is high.

The majority of sites located during the Mississippi Chemical survey are located in dune environments (48 percent), while 24 percent occur on or near cliffs. Although no pithouses or surface structures were reported in this survey, they are suspected, since a large pithouse village has been reported just south of the proposed plant site.

To recapitulate, site densities within the potash basin may be expected to range between 12 and 15 sites per square mile. The majority of sites will be located in dunes, on cliffs, in close proximity to playas, or a combination of these. The majority of sites will be of the Archaic and Jornada Mogollon time periods, with pithouses and surface structures not uncommon.

At present, Executive Order 11593 and the Historic Preservation Act of 1966 have not been fully complied with. A partial inventory has been completed and will continue until the basin is completely inventoried. The partial inventory undertaken for this EAR has revealed two National Register quality Districts; Laguna Plata and Maroon Cliffs. The State Historic Preservation Officer has been consulted, and at present these two sites are being prepared for nomination by him. A number of sites were found suitable for nomination to the State Register, and these are also being nominated by the State Historic Preservation Officer.

The following section relates to Historical Register information and was prepared after consultation with the State Historical Preservation Officer. A number of sites in the potash basin are already on one of these two registers. Two properties presently undergoing the nomination procedure are the site of Project Gnome and Pope's Wells.

Project Gnome was the first peaceful underground atomic detonation, and the location choice partly resulted from the presence of plastic salt beds which could absorb the explosion force. ERDA has requested that the nomination of the Project Gnome site to the National Register be held in abeyance until further notice. Pope's Wells were dug by Brevet Captain John Pope in the hope of providing water for a proposed railroad line across southern New Mexico. The project was interrupted by the Civil War and the railroad was never completed.

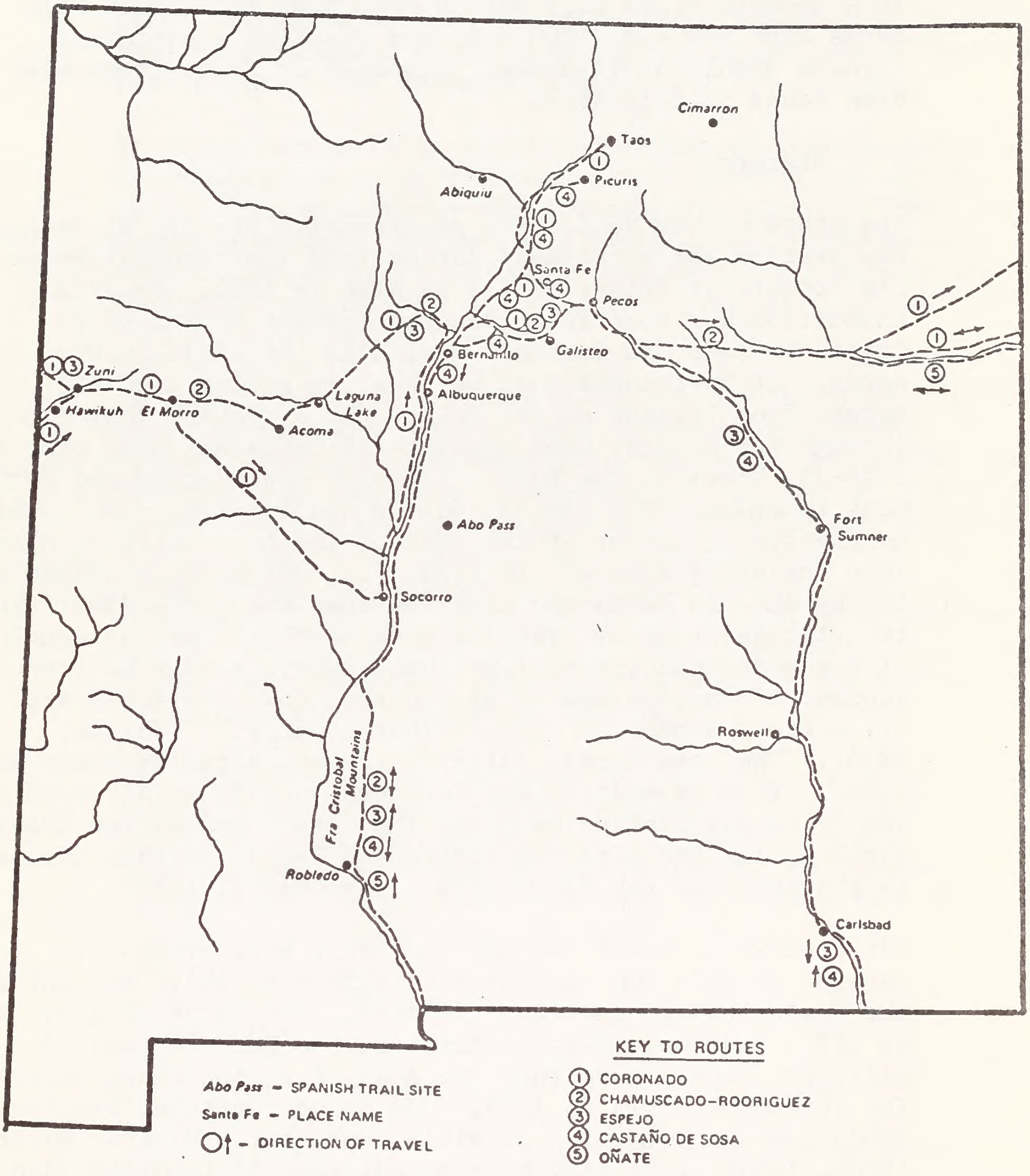
Sites on the State Register include Rattlesnake Draw, Monument Springs, Lusk Ranch Site, and Boot Hill. These sites are all located on private land. Rattlesnake Draw contains the best stratigraphic sequences found to date in southeastern New Mexico, while Monument Springs consists of pithouse ruins and a large midden. The site has yielded materials from Clovis through Comanche. The Lusk Ranch Site is a mammoth-bison kill dating from 9000 B.C. Boot Hill dates from 900 A.D.-1300 A.D. and contains a series of Jornada Mogollon pithouses. A number of trade items have been found in this site.

4. History

The State of New Mexico has an extensive history of Spanish exploration and settlement dating from the reconnaissance of the Franciscan friar, Marcos De Niza in 1539. De Niza's expedition was sparked by reports brought to Mexico by Cabeza De Vaca, of enormous wealth in the lands to the north. It is thought that De Vaca, in making good his escape from Indians on the Gulf Coast of Texas, passed through New Mexico, near present day Carlsbad, some time in 1534-35. However, the bulk of Spanish exploration and settlement tookplace from the Rio Grande Valley west, and in the northeastern quarter of the state. The next entry by Spaniards into the study area was in 1583. In that year, an expedition led by Antonio De Espejo traveled down the Pecos River from the village of Pecos, enroute back to Mexico at the conclusion of his more northern explorations. Dspejo's only written account of what he saw on his journey down the Pecos was "...a great number of cows of that country." (Bolton, 1916). The cows Espejo referred to were actually American bison. This expedition was followed in 1590 by an expedition led by Gaspar Castano De Sosa. The Sosa's expedition traveled north up the Pecos to the village of Pecos and then crossed to the west and the Rio Grande. (See Map II-15).

After De Sosa passed through the study area, there are records of only two significant entries by white men until the coming of the cattlemen in 1866. The first of these was in 1775, when Commandant-General Hugo O'Conor conducted military campaigns against the Apaches in the Pecos Valley. The second occurred in 1854, when Brevet Captain John Pope conducted a survey of a possible route for a Pacific Railroad. (Pope, 1854) Following this expedition, in 1855 and 1858, Pope drilled three wells east of the Pecos in the vicinity of the New Mexico-Texas Border. These well sites are within the potash Study Area. They have been listed on the New Mexico State Register of Historic Sites and have been nominated to the National Register of Historic Places.

MAP II-15 MAJOR SPANISH EXPLORATION ROUTES IN NEW MEXICO



From: The historic preservation program for New Mexico, Vol. II
New Mexico State Planning Office, Santa Fe, 1973.

In his report of the 1854 exploration, Pope extolled the potential of the area adjoining the Pecos for irrigated farming and the excellence of the grama grass for grazing. A railroad was not constructed along this surveyed route due to events leading up to and the advent of the Civil War.

During the period from 1590 to 1866, the Study Area continued to be inhabited by wandering bands of native American Indians. These Indians were predominantly Lipan (Apaches). It is possible that occasional parties of Jumanos, Mescaleros, Comanches and Kiowas, may have crossed through the Study Area on hunting or raiding forays (See description of the existing environment - cultural resources). With the coming of the cattlemen in 1866, there were still occasional encounters between the white man and the Indians, but these were infrequent, and by the 1880's the Indians were no longer a significant presence in the area. During this same time period, titular ownership of New Mexico was changing first from Spain to Mexico (1821) and then from Mexico to the United States (1848). However, the Study Area played no role in these activities other than being a very small portion of the large tracts of land which were changing hands.

It was indeed the coming of the cattlemen, led by Charles Goodnight and Oliver Loving in 1866, that initiated the blossoming of southeastern New Mexico history. When the army and the Indian Bureau called for bids to furnish beef to feed the Navajos and Mescalero Apaches who had been forced onto a reservation at Fort Sumner, New Mexico, the local ranchers and farmers could not meet the demand. It was then that Goodnight and Loving gathered a mixed herd from cattle-poor Texas ranchers and made their daring drive across the southern portion of the Llano Estacado and up the Pecos River to Fort Sumner. Since this venture was successful, John Simpson Chisum, in the following year of 1867, followed the trail broken by Goodnight and Loving to Fort Sumner. However, the beef contractors would not accept that portion of the herd which was cows with calves. This being the case, Chisum located these "unacceptable" cattle on the range south of Fort Sumner. With the addition of similarly "unacceptable" cattle from subsequent drives, Chisum eventually had cattle grazing from Fort Sumner along the Pecos, all the way to the Texas border. As an offshoot from these cattle drives, "trading posts" catering to the needs of the cowboys began to appear, and thus the settlement of southeastern New Mexico was begun. One such "trading post" was located near present day Malaga. (Myers, 1965-70, pps. ii-iii). In 1884, another cowman by the name of Charles Bishop Eddy appeared on the scene. Eddy had ideas about irrigating lands in the Pecos Valley, and inspired by similar ideas held by ex-lawman, Pat Garrett, of Billy the Kid fame, founded the Pecos Valley Land and Ditch Company in 1888. Eddy's company acquired land and sold lots in the town site of Eddy, currently Carlsbad. The company constructed a dam north of the town on the Pecos, built irrigation ditches and canals, and planned to construct a railroad from Pecos City, Texas to Roswell, New Mexico. By 1897, all of these projects were completed and the name of the town had been changed from Eddy to Carlsbad.

During the period from 1888 to 1897, Mexican nationals were employed to work on the irrigation and railroad projects. In 1891, through the efforts of J. J. Hagerman, a Swiss colony of agriculturists was established at Vaud, now Loving, and in 1892, a group of about 65 Italians purchased lands for farming near Malaga. In addition to these two groups of foreign colonists, there were small groups of Chinese and blacks living in or near the community of Eddy. (Myers, 1965-1970).

In the twentieth century there have been several major cultural and economic events in the vicinity of the study area. The Hammond and later the Brown well produced oil near Artesia in 1909. Oil drilling led to the discovery of potash in the Snowden and McSweeney McNutt No. 1 well in 1925. An event of international significance, Project Gnome, ocurred in December, 1961. This was the first underground test to develop nuclear explosives for peaceful purposes. The Gnome site is in the process of being nominated to the National Register of Historic Places.

5. Socio-Economic Conditions

a. State of New Mexico Demography

In 1970, New Mexico had a total population of 1,016,000 people. The population density of 8.4 persons per square mile is substantially below the 57.3 national average. The state realized a population increase of 6.8 percent in the 1960-1970 decade.

Since 1910, New Mexico has realized an increasing urban population. In 1970, approximately 69.8 percent of the population resided in urban places of 2,500 people or more. The percent of urban population was only 14.2 percent in 1910.

b. Southeastern New Mexico Economic Development District

The District is a federation of county and muncipal governments from Chaves Eddy, Lea, Lincoln and Otero Counties. The District covers New Mexico Planning and Development District No. 6.

By forming this federation, the local governments have erased the restraints of muncipal and county boundaries and barriers in the problem solving and planning process. The District is a technical liaison, dedicated to efficient realization of its member's needs, through assistance by state and federal government programs and services.

The District covers approximately 16,746,300 acres, which amounts to 21 percent of the State's total acreage.

(1) Demography

The District's population grew from 134,280 in 1950 to 206,581 in 1960. In the next 10 years the population declined to 182,665. This was mainly due to a decrease in agriculture, oil and potash industries, and the closing of Walker Air Force Base in Roswell. The population density was about 7 persons per mile compared to the State's density of 8.4 persons per square mile. The District's 1970 population was mostly urban.

Approximately 75 percent of the population resided in urban places of 2,500 people or more. This was slightly higher than the 69.8 percent for the State.

c. Carlsbad Potash Study Area (Socio-Economic Profile Area)

The Study Area for purposes of evaluating the Socio-Economics of the Potash Industry is comprised of Eddy and Lea Counties which make up the Socio-Economic Profile Area (SEPA). The primary purpose for establishing this SEPA is the similarity of social, economic, cultural, and infrastructure characteristics around the major potash trade center.

The SEPA covers an area of almost 5-1/2 million acres, which is about one-third of the total area comprising the Southeastern New Mexico Economic Development District.

(1) Economic History

(a) Eddy County

Eddy County was carved out of Lincoln County in 1889 and named for Charles B. Eddy, who played a leading role in the early development of the area. The county does not figure prominently in early New Mexico history. It had no settled communities, such as the northern pueblos, its only inhabitants being unfriendly nomadic Indians. After the destruction of the buffalo herds, the area furnished grazing for large live stock ranches formed in the southeastern part of New Mexico. This industry was the base of Eddy County until development of the irrigation potential of the great limestone aquifers west of the Pecos River gave an impetus to agriculture, which dropped the livestock industry into second place.

During the period after the Civil War, the Eddy County area, in common with the great plains to the east, was used for cattle raising. In the Carlsbad area, in the 1880's, the Eddy-Bissel Cattle Company was virtually the sole commercial activity.

By 1900, Eddy County had a population of three thousand persons. About 13,000 acres were under irrigation when a flood on the Pecos River washed out the Avalon Dam. Unable to obtain financial resources to repair the damage, the irrigation system was turned over to the United States Reclamation Service by the Pecos Irrigation and Investment Company, who originally built the dam. The Reclamation Service rebuilt the dam and extended the system to a maximum capacity of 25,000 acres.

Around 1920, the Carlsbad area was almost entirely a trade and distribution center, serving the surrounding agricultural and livestock needs. The 1920 census reported the population at 9,116.

In 1923, the Carlsbad Caverns were established as a National Monument, and by an Act of Congress in 1930, the caverns were made a National Park. Developments were made in the cavern area and the number of visitors per year increased. In 1924, the attendance was 1,876, and by 1930 visitations increased to 91,462.

Oil was discovered in Eddy County in 1909, and the first potash mining company moved into the county in 1927. In terms of employment, agriculture maintained its ascendancy until 1940, but in the following years fell far behind the mining industry in both revenue and employment. In 1940, agriculture employed 22.8% of the county's workers as compared to 18.7% for mining. By 1960 the figures were: Agriculture 8.6%, Mining 26.9%.

Eddy County's crude oil production is almost twelve times as valuable as that of the county's natural gas output, but the new Indian Hills Gas Basin west of Artesia may reduce those odds. Much interest is also centered in deepwell developments in Eddy County's portion of the Delaware Basin. According to the New Mexico Oil Conservation Commission, Eddy County contains eight of the State's fifty-five oil fields, which in 1965 maintained a minimum production rate of 1,000 barrels a day.

Eastern Eddy County got two new oil fields in 1966, one of them the important Eddy Big Strawn. In 1962, the Indian Hills Basin was opened west of Carlsbad and Artesia, and has provied to be one of the State's most important new gas finds. That area now has more than sixty operating wells (each of them reportedly representing a quarter-million dollar investment by the driller), and gives every promise of becoming one of the nation's most productive gas areas. Some wells are capable of releasing over 100 million cubic feet of gas a day. Marathon Oil's new multi-million dollar processing plant and gathering systems are located there. The plant went on stream in December 1965, with a daily capacity of 180 million cubic feet. Most of its processed gas goes to the West Coast via Transwestern pipelines.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

The economy of Eddy County declined sharply in 1968, and continued in 1969, mainly because of the potash industry's cutback in labor force. The sharply declining potash employment started in the latter part of 1967. Employment by the potash industry should now be stabilized, or possibly a small increase should take place.

Two factors that tended to stabilize Eddy County potash production came about in December of 1969. After many months of delay, the U. S. Treasury Department released their findings on the potash investigations initiated at the request of Carlsbad people. The U. S. Tariff Commission found that potash from Canada, France, and West Germany was being sold at below its fair value in the country.

After hearings, the U. S. Tariff Commission determined that the domestic industry was injured. This resulted in the Federal Administration being required to assess duties from these countries. The Canadians, in an attempt to stalemate the assessment duties on potash from Canada, placed a production quota on their potash production and established a price per ton at almost double the price at which they had been selling potash in this country. This has allowed the local potash industry to maintain the industry in a way that benefits both the local economy and the nation.

(b) Lea County

Lea County was created by the State Legislature on March 7, 1917 from the eastern portion of Chaves County and Eddy County. It was named for Captain J. C. Lea, who was an early Pecos Valley settler and developer. Lovington, whose residents had been instrumental in leading the movement to create the county, was made its seat of government. Lea County is unique in the state because it has no running streams or naturally occurring standing surface water within its boundaries.

Although permanent settlement in Lea County has come only in recent years, its area was familiar to Apache, Comanche, and Kiowa Indians, who traveled and camped there extensively while hunting buffalo. These animals were especially plentiful in the days before the coming of the Spanish explorers. The grass cover was apparently excellent then and even without surface water, the region made a good spring breeding home for large herds of buffalo.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

The Llano Estacado plateau which stretches from the Canadian River in New Mexico and Oklahoma for some 400 miles, is an area striking in physical appearance and long a place of hardship for travelers. Indeed, at one time in the 1800's, because of the lack of water, it was closed to exploration by members of the United States Army. Known as the Staked Plains, its name has provoked nearly as much debate as its features have provoked discomfort.

Whatever its origin, the Llano Estacado was a popular seasonal resort for buffalo, and for a while, a profitable hunting ground. In the 1870's and 1880's hunters rode throughout the plains, killing herds as they went. Their zeal finally ended their livelihood, for by the middle 1880's they had slaughtered all of the buffalo that were left.

Several significant ranches were established in the county area in the early 1880's, and for several decades livestock raising was the prime economic activity. The four Camden brothers moved from Texas in 1883 to the vicinity of the present community of Jal, and with their several hundred head of cattle, founded what later became the J. A. L. Ranch. One of their relatives, Walter Cochran, started the Mule Shoe Ranch on the townsite. That same year the Littlefield Cattle Company's L. F. D. Ranch was established in the Four Lakes area, and in 1884 the Dug Springs or T. A. X. Ranch began operations twenty miles south of Monument Spring.

During the remainder of the decade, the area's livestock raising popularity grew, and a number of other ranches were developed. The yearly rainfall that the grass cover remained adequate, and sheep and cattle became the economic base of the region. Windmills could be seen in increasing numbers as the abundant shallow ground water was pumped in growing volume to water the livestock.

Following these early ranchers, came homesteaders who spread out over the flat landscape and often took up dry farming, which soon became a second industry. A limited amount of windmill irrigation was carried on, and the alfalfa crops that resulted were used as feed for the growing herds of sheep and cattle. By the turn of the century, farming was establishing itself as a significant enterprise, even though it was uncertain, because of the low average annual precipitation. Only about one year in five yielded a really successful crop.

As homesteaders continued to flock to the county, it was inevitable that towns would develop, and so in the first decade of the 20th Century, platting and building began. The early towns were by no means large, but the county nevertheless began a period of community development. King was a homesteading period village, as was Plainview. Many small rural schools were built to serve the children of these early settlers. In 1907, just after the turn of the century, B. B. Knowles established a post office and store about a mile from the townsite that was to be named after him.

The James Isaac Hobbs family moved from central Texas to the site of Hobbs in covered wagons. The first school in the village served also as a Methodist church and a theater. Lovington was first settled in 1908, and in its earliest days, free building lots were given to patrons of the school. The need for a school in that area was one of the reasons for the town's creation. Eunice was founded in 1909 by J. N. Carson, who had homesteaded there and opened a post office and store, the merchandise for which was hauled in by team from Texas. That same year, Tatum was settled by J. G. Tatum. The following year a post office opened in the new village of Jal.

In 1919, Powhaten Carter of Lovington showed the first interest in oil when he obtained leases on land in the east central part of the county and sought after someone who might want a drilling contract. Soon after, the Ranger Lake Oil Company took leases to the north. Drilling contracts, however, were not forthcoming and so nearly without exception, these early leases were allowed to lapse. In the 1920's, new activity across the state line in Winkler County, Texas, again aroused oil interest in Lea County, this time in its southern reaches. Leasing began here in 1923, and by 1926, speculators from outside the county were taking leases on land not only in the south, but more and more in the north again. Geophysical prospecting crews began investigations all around the county in that year. After wells at Jal and Hobbs came in at depths of just over 4000 feet, the rush began in earnest, and twenty-one oil companies began drilling. The first production of oil began in November, 1927, and soon the South Jal, Hobbs, Eunice, Cooper, Monument, and Lynn fields were yielding oil plentifully. By the end of 1928, oil production was significant, and the county's future looked bright. Refineries were soon erected at Hobbs, and pipelines were laid to Sonora, Mexico, and to connections with the West Texas and Gulf System. Towns that had once held only a few hundred settlers, suddenly filled with immigrants from other counties and other states, all eager to share in the new wealth. Early homesteaders who had struggled through drought and failing crops now found themselves collecting handsome sums from their oil leases. In the midst of this scramble, State officials and oil producers wisely adopted prorationing laws to ensure a more orderly exploration of a non-replenishable commodity. In 1930, the county's importance was given added recognition when the Texas-New Mexico Railroad built tracks into Hobbs.

The early boom days were not to continue uninterrupted, however, for the depression which had begun to sweep the country in 1929, settled on Lea County also. Oil activity, most of which was centered then in the Hobbs area, suffered a letdown. Prorationing and new activity in the east Texas fields also helped dampen the runaway surge of Lea County's industrial beginnings. Many workers left for the Texas fields, but most of those who stayed, began to find themselves without work. Hobbs shrank to at least one-tenth of its boom population, and for nearly three years activity in the county was practically at a standstill. But in 1934, drilling was renewed, and towns such as Hobbs began their recovery.

(2) Demography

In 1970, the Study Area had a total population of 90,673 which was almost one-half of the total population in the Southeastern New Mexico Economic Development District (SENMEDD). The Study Area realized a population decrease of 13 percent in the 1960-1970 decade, while the SENMEDD experienced a 11.6 percent decrease in the same time period. The population density of 10.6 persons per square mile in the Study Area was higher than the 7.0 density for the Development District. (Appendix C-1 and 2).

Carlsbad Potash Study Area (Socio-Economic Profile Area)

The majority of the Study Area's 1970 population was urban. Almost 80 percent of the population lived in urban places of 2500 or more people. This was about 5 percent higher than 74.9 percent for the SENMEDD.

Population estimates by the Bureau of Business Research Appendix C-3 indicates a small increase in population in the Study Area for 1974, while the population density remained at 10.6 persons per square mile. These estimates show a population increase of 846 in Lea County from 1970 to 1974 and a decrease of 719 for Eddy County.

(3) Socio-Economic Characteristics

(a) Population

Appendix C-4, 5, and 6 in the Socio-Economics Appendix indicate population distribution by age, sex, ethnicity, and education level of persons 25 years old and over.

The majority of the Study Area 1970 population (61.9%) was between 15 and 64 years of age. The 25-44 years and 45-64 years age groups together accounted for 44.7 percent of the population, and persons in the 0-14 years age bracket made up 31.2 percent of the total population. The population distribution by sex was almost even in the Study Area, as 50.8 percent were female and 49.2 percent were male.

The ethnic distribution indicates that 95 percent of the 1970 population was racially White and that 21.7 percent of all Whites were Spanish surnamed. Minorities accounted for 25.5 percent of the total population. The percentage of Blacks (3.9%) in the Study Area was twice the State's percentage.

The total population 25 years and over in the Study Area was 46,970, which was 51.5 percent of the total 1970 population. Slightly over one-half (50.3%) of the total females 25 years and over have completed high school, and 48.1 percent of all males 25 years and over are high school graduates. The median number of school years completed was 11.7 years for males and 12.0 years for females which is very near the 12.1 national average. The Study Area's percentage (49.3%) of persons 25 years and over with four years of high school or more is slightly below the 52.3 percent National average.

The Study Area has a lower percentage (7.9%) of persons with four or more years of college than the 12.7 percent State average and 10.7 percent national average. Because of the lack of business opportunities and reduced needs of small population for professional services, it is likely that people with four or more years of college education would find work in larger urban centers, both in and out of state.

(b) Employment

This section analyzes particular employment trends that have developed during the decade 1960 to 1970 and some discussion on 1973 and 1974. An overall view of predominant employment within the Study Area as a whole is discussed; only significant employment sectors are discussed and conspicuous trends are noted (Appendix C-8 through 14)

In 1974, total employment was 31,500 persons, down 8.2 percent from 1970. The unemployment rate in 1970 was 5.1 percent and dropped to 4.8 percent in 1974, as compared with a 1974 statewide ratio of 6.3 percent (New Mexico Progress 1974 - Summary Economy).

Within the Study Area in 1970 (Appendix C-8 and 9, Social Economics Appendix), the Mining (petroleum, natural gas, potassium salts (Potash)), Trade, Services, and Government sectprs were the principal employers with 22.6 percent, 17.1 percent, 10.5 percent, and 12.5 percent of the total employment, respectively. In 1974, the percent employment for these major sectors was mining 27.5 percent, Trade 22.0 percent, Service 13.4 percent, and Government 12.7 percent. The most immediately noticeable trend in the Study Area is the percentage employment decrease in agriculture from 7.1 percent in 1970 to 3.3 percent in 1974, and the increase in mining to 27.5 percent in 1974 from 22.6 percent in 1970.

(c) Income

This section describes the 1969 income levels and distribution for the Study Area as a whole.

Total personal income in 1959 was $214,300,000 in the Study Area and increased to $301,700,000 in 1969. Per capita income in the same ten year period increased from $2,128 to $3,294, as compared with the statewide 1959 per capita income of $1,914 and the 1969 per capita income of $2,877 (Appendix C-17). Personal income increased 19.2 percent from 1969 to $360,000,000 in 1973. Per capita income increased from $2,877 in 1969 to $4,008 in 1973. (Appendix C-18). The amounts and percentages of the 1969 personal income derived by principal sectors was mining $71,117,000 (23.6 percent), Government $33,110,000 (11 percent), and Agriculture $23,369,000 (7.8 percent) (Appendix C-19 and 20).

The Study Area mean family income in 1969 was $9,210. This exceeded the State mean family income of $9,193. The mean family income ranged from $8.851 in Eddy County to $9,568 in Lea County. The median income for the 23,668 families in the Study Area was $8,287, compared to the $7,849 median income for the State. (Appendix C-15).

In 1960, 15.9 percent of the total number of the families in the Study Area were under the poverty level. The percentage of families under the poverty level decreased to 14.8 percent in 1969 (Appendix C-16).

(d) Housing

This section describes the 1970 housing situation within the Study Area. An assessment is made of housing trends specific to the area, with a more detailed description of housing conditions such as occupancy, structure age, plumbing facilities, crowding, value of owner occupied housing, and contract rent for renter occupied housing. Appendix C-22 through 27 illustrate various housing conditions, using 1970 census of housing data as the primary data source.

(1) Occupancy Characteristics

The total population in year-round housing units was 89,782 in 32,044 units. Household size (the number of persons per occupied housing unit) was 3.3 similar to the statewide average of 3.4 persons per unit. Owner occupied units account for 59.6 percent of the total housing units in the Study Area, while only 26.3 were renter occupied units. The percent vacant of all year-round housing units in 1970, within the area was 14.1 percent, exceeding the 10.2 percent for the State (Appendix C-22).

(2) Structure and Age Characteristics

While single family structures constitutes the greatest percentage of housing units (89%) within the Study Area, the mobile home is beginning to assume a greater proportion of the year-round housing stock. This situation is especially true in the rural areas and places which have experienced rapid and substantial population growth. Multi-family units account for only 6.7 percent of the total year round units in the Study Area (Appendix C-23). About 59 percent of the total housing units within the Study Area were built since 1950, 20.6 percent since 1960, and only 15 percent prior to 1939. These age characteristics are similar to the characteristics of the State as a whole (Appendix C-24).

(3) Plumbing and Crowding Characteristics

Differences in the percentage of housing which lacks some or all plumbing facilities is quite pronounced when comparing the Study Area (3.7 percent) to the statewide average (10.0 percent). In Eddy County, about 5 percent of the housing units lack some or all the plumbing facilities while the percentage is only 2.4 percent for Lea County. Generally, crowding conditions (persons per room greater than 1) are less for the Study Area (10.0 percent) than the 13.8 percent statewide average (Appendix C-25).

(4) Value of Owner Occupied Housing and Contract Rent of Renter Occupied Housing

The median value of owner occupied housing units only differ by $400 between Eddy and Lea Counties. The median value was $10,800 within the Study Area, slightly below the $13,100 statewide median. The majority of the owner occupied units within the Study Area fall into the $5,000 to $15,000 range (Appendix C-26).

Median contract rent of renter occupied rental housing units within the Study Area was $60 which was below the statewide median of $72. Contract rent in the $40 to $80 range accounted for 54 percent of all renter occupied housing units in the Study Area (Appendix C-27).

(e) Education

In the Study Area, there are eight school districts, the three in Eddy County are consolidated while the five in Lea

County are independent. The combined average daily membership in public schools for the 1974-75 school year was 21,833 students, accounting for only 7.98 percent of the states total (Appendix C-32). The Study Area has a total of 44 elementary schools, 15 junior high schools, 1 mid-high school, and 6 senior high schools in the public school system. The Study Area's two largest school districts, Carlsbad and Hobbs, accounted for 61.5 percent of this total (Appendix C-32).

The average annual expenditures for the 1970-71 pupil enrollment of 24,637 was $17,252,079. This amounted to a $700 expenditure per pupil. The average pupil to teacher ration was 23 to 1 (Appendix C-28).

In the 1970-71 school year, the Study Area school districts derived almost two-thirds of their total funds (65.7%) from state revenues, 33 percent from local revenues, and only 1 percent from federal sources (Appendix C-29).

In the Study Area, the 1970-71 school year enrollment in other educational facilities included 320 pupils in parochial schools, 2870 students in junior colleges, 513 students in 4-year colleges, and 713 students enrolled in vocational training (Appendix C-30).

The 1973-74 public school enrollment in the Study Area was 22,599, down 8 percent from the 1970-71 school year, of this total about one-third 33.1 percent were enrolled in grades 9 through 12 (Appendix C-31).

Eddy County

There are only three districts in the Eddy County public school system. These are Artesia, Carlsbad, and Loving districts. Senior high schools are located in Artesia and Carlsbad. One parochial school, St. Edwards in Carlsbad, offers instruction through the elementary and junior high grades.

In addition to its senior high school, Artesia has two junior high schools and eleven elementary schools. Carlsbad has one senior high school, one mid-high, two junior high and twelve elementary schools. Three rural schools, located at El Paso Gap, Otis, and Malaga, are included in the Carlsbad district. These provide instruction in the elementary and junior high school grades. Loving has one elementary and one junior high school. High school students attend school in Carlsbad.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

Eddy County schools are attractive, well equipped, and well staffed. They appear to enjoy solid public support and offer some interesting features. Abo Elementary School in Artesia is underground, and combines an underground shelter with the school. Yucca Elementary, also in Artesia, is a windowless school, its climate controlled by a heating-air conditioning plant. The Artesia Christian College is an independent, liberal arts institution, employing the tutorial system, team teaching, and other desirable features.

There is little doubt that consolidation of schools has resulted in a better school plan, better equipment and facilities. This, in turn, attracts better qualified teaching personnel. However, the cost of transporting students to and from the consolidated schools is considerable, both in time and money. During the 1966-67 school year, the Carlsbad district transported 2,597 students over a distance of 200,880, miles at a cost of $158,610. The average one-way bus route was 27 miles, the annual per capita cost $61.07. The Loving District transported 235 students a total distance of 38,700 miles, at a cost of $21,540. The average one-way distance was 21 miles; the per capita cost $91.65. The Artesia District transported 1,378 students a total of 278,820 miles, at a cost of $123,075. The per capita cost was $89.31; the average one-way bus route 30 miles.

The County's school population began a decline in the 1966-67 school year. Average daily membership in Carlsbad schools reached a maximum of 9,255 in the 1965-66 school year, and dropped to 8,740 during 1966-67, the lowest since 1961. Average daily membership at Artesia has been in decline since the 1962-63 school year when it reached 4,801. The figure for 1966-67 was 4,530.

At Carlsbad there is one institution of higher learning, which is a branch of New Mexico State University. The presence of this school contributed to improvement of educational levels, which had not previously kept pace with economic advances.

Eddy County total attendance in the three school districts during 1970-71 was 7,416 in elementary schools, and 3,726 in secondary schools. Theaverage cost was $663.08 per student. Of this, $66.19 was for transportation, student activity, community service, etc.

Carlsbad Potash Study Area (Socio-Economic
Profile Area)

Source: Overall Economic Development Program, Phase 1,
SENMEDD, 1972

(2) Lea County

Lea County has not followed the statewide pattern of consolidation of school districts. Since 1952, the county has had five school districts, and movements toward consolidation receive no support from the communities involved. Each of the five districts in the county enjoy a relatively good financial situation. The oil fields, upon which the entire county is situated, provide excellent school revenue that local people are not anxious to share with other districts which might be less fortunate. Also, in these oil field towns, the schools are usually the most impressive buildings and function as a local point of community activity and pride.

The school buildings in each district are relatively new and well maintained. Athletic facilities are excellent. Attendance in the public school varies a great deal due to fluctuations of activity in the oil fields. All districts report nearly a twenty-five percent turnover in enrollment over the course of a year, reflecting a very transient working population.

The Tatum School District is the smallest in Lea County, with 1968-69 average daily membership of 534 students. During that year, Tatum's total operational fund expenditures were $632,852, for an average cost of $818 per pupil. This district employed 28 full-time teachers in 1968-69. The faculty had an average of 13.2 years teaching experience and an average salary of $8,247, third highest in the State. Classroom teaching loads were lighter than in Lea County's larger districts. No elementary school teacher had classes with more than 31 pupils. Fewer than four percent of the classes taught in the junior and senior high schools had more than 30 students.

The elementary and high school are located on a single campus in Tatum. The oldest building on the present campus is the grade school gym, built in 1943 at a cost of $75,000. From 1950 through 1965, the Tatum school system has steadily constructed new buildings and additions.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

The Tatum School District covers a larger area than any other district in the county. In 1968-69, the district spent $58,547 transporting 270 students to and from school. The per pupil cost, $216.84, was the highest in the county and is accounted for by the length of the bus routes which averaged 41 miles in each direction. The longest route, one way, was nearly 70 miles.

The Lovington District is the second largest in Lea County. Its average daily membership for 1968-69 was 3,352, seventeenth largest in the State. This district's total operational fund expenditures in 1968-69 were $2,260,214, sixteenth largest in the state. The average cost per pupil was $590, which was higher than the statewide average of $488.

The Lovington System has one high school, two junior high schools and five elementary schools. The Lovington district transported 826 students to and from school at a total cost of $108,561 during the 1968-69 school year. The average length of the bus routes was 31 miles in each direction.

The Hobbs School District, with an average daily membership of 8,396 during school year 1968-69, is the eighth largest in the state. The district's total operational fund expenditures in 1968-69 amounted to $5,056,962, sixth highest in the state, and highest in Lea County. The average cost per pupil, based on net operational expenditures, was $555, the lowest in the county. The district is the only one in the State that owns an oil well. This was a gift from a Texas benefactor, and produces $15,000 annually.

The Hobbs School System is comprised of ten elementary schools, three junior highs and one senior high school.

The only parochial school in Lea County is St. Helena's elementary school in Hobbs. About 105 students attend grades one through six. This small school, opened in 1960, has suffered a decline in enrollment over the past few years. Tuition is $7 per month per child, but no family is charged more than $14 per month. All non-Catholic students pay $14 per month.

Operating fund expenditures for the Eunice School District in 1968-69 amounted to $842,851. The district's average daily membership was 979, second lowest in the county. The average cost per pupil was $776, second highest in the county.

The elementary, secondary and the administrative offices are located on a single campus in Eunice. The main elementary classroom building is the only one built before World War II. The other buildings were constructed and added to at a steady pace from 1955 through 1968. All 12 buildings were completely air-conditioned in 1968.

The Jal School District's average daily membership during school year 1968-69 was 960. The district's total operating fund expenditures for this year amounted to $808,426. The average cost per pupil was $725.

All of the school buildings and the administrative offices are located on a single campus in Jal.

In 1963, the New Mexico State Legislature enacted the Junior College Act. This law extended to the political subdivisions of the state, the opportunity to voluntarily tax themselves for the support of educational facilities beyond the high school level. The first junior college district to be formed under the law is composed of the public school districts of Tatum, Lovington, Hobbs, and Eunice. Taxable property in this "super district" is assessed at more than $200 million.

New Mexico Junior College, located near Hobbs, promises to become one of the area's most important educational institutions. The campus is located three miles north of Hobbs, and is perhaps the only significant recent work of architecture in the county. More than 1,000 students were enrolled during 1968-69. Free transportation is provided to the campus from each town in the district. About 25 teachers made up the faculty in the academic division and about the same number were on the staff in the technical vocational division.

The College of the Southwest opened in 1956 as a two-year junior college. It was then called Hobbs Baptist College. In 1958, it began to offer third and fourth-year courses and changed its name to New Mexico Baptist College. In 1962, the college moved to a new three-building, 160-acre campus five miles north of Hobbs, and under a new charter was renamed College of the Southwest. This is a small, church-sponsored institution that receives no support from public taxation. All funds are from tuition, fees, and gifts. The present faculty numbers 25, and student enrollment for 1969-70 was about 150. This college faces problems of survival as a viable educational institution. The opening of the junior college has sapped its tuition-paying enrollment and much of the community support it enjoyed when it was the only college in the county.

Lea County total attendance in the five school districts during 1970-71 was 9,121 in elementary schools and 4,374 in secondary schools. The average cost was $730.94 per student. Of this, $52.70 was for transportation, student activity, community service, etc.

(4) Health and Social Services

Encompassing a broad range of medical and helping services, health and social services are a vital element in the socio-economic environment of the Study Area. Although often functioning in much the same manner, each incorporates a far different perspective. Best viewed as separate, but complimentary service sectors, the following discussion deals with each as a distinct element in the socio-economic environment.

(a) Health

Some of the factors determining economic growth potentials or constraints, encompass the quality of life afforded by the environment, the general health status of the people, and the availability of medical care and services.

The Study Area's climate provides an environment, which with regard to healthful living, is matched by few other areas. Major environmental hazards such as air pollution, water pollution, and solid waste disposal have not yet become the serious problem already encountered in other areas or states.

The real problems do not stem from the quality of care available, but rather low ratios between physicians, dentists, and nurses, and population; long travel distances from isolated communities to existing health facilities; low income and high unemployment among people needing medical attention; and the ever increasing high cost of medical care.

Generally, if health services, facilities, and manpower are available within a healthy environment, the potential for growth in other areas of economic endeavors is enhanced; on the other hand, when health resources are lacking, the conditions are evident only as a small segment of a host of social ills. In this sense, even the most obvious health related potentials for, or constraints against, economic growth in the Study Area are subject to the development or lack of development of the other forces which tend to stabilize or weaken the economy.

With both preventive and curative functions, ranging from diagnosis to treatment and supervision of physical, mental, emotional, and social problems, the health services available to a community are both broad and diverse. The following discussion centers upon the three primary elements in the health care system - - manpower, facilities, and services in the four major cities in the Study Area (Artesia, Carlsbad, Hobbs, Lovington).

(1) Manpower

The various categories of health manpower include physicians, dentists, nurses (R.N.'s and L.P.N.'s), optometrists, osteopathists, and chiropractors. Due to the sparsely settled development pattern in the Study Area, the distribution of health manpower has developed into a general pattern of urban adequacy and rural scarcity.

Health manpower in the Study Area for 1974-75 consisted of 62 medical doctors, 23 dentists, 9 chiropractors, 7 osteopathists, 9 optometrists, 198 registered nurses, 81 licensed practical nurses and 6 physical therapists. In Eddy County the ratio of physicians was 0.9 per 1000 population, while the ratio for Lea County was 0.6 per 1000 population.

Table II-73 Health Manpower 1974-75

	Lea County		Eddy County	
	Hobbs	Lovington	Artesia	Carlsbad
Medical Doctors	31	6	5	20
Dentists	8	2	3	10
Chiropractors	3	1	1	4
Osteopathists	2	2	2	1
Optometrists	3	1	2	3
Reg. Nurses	(81)*		(117)*	
Lics. Practical Nurses			(131)*	

*County totals.

Source: New Mexico Department of Development, Community Profiles, 1974-75

(2) Facilities

There are six general hospitals and two long-term nursing homes, within the Study Area, with a total bed capacity of 449. The average annual occupancy of all facilities varied from 46 percent to 68 percent. The five days of highest census show an occupancy rate range from 60 percent to 124 percent. The average length of stay was from 4.4 days to 6.2 days. Based on the average annual vacancy rate (utilization rate), the Study Area has sufficient bed capacity.

(3) Services

Besides in-patient and out-patient medical services, the health care system in the Study Area offers a wide variety of social and rehabilitation services. In the Study Area, these services are coordinated by the various local offices under the New Mexico Department of Health and Social Services.

(4) Eddy County

Eddy County's major cities are Carlsbad and Artesia, with a total population of 34,612, which is 38 percent of the Study Area 1970 population. The county population is composed of 3,660 persons 65 years old and over. This is 58 percent of the Study Area's population 65 years old and over.

The county area is 4,180 square miles and is basically composed of mountains, valleys, and mesas.

The population per square mile is 9.8 and the maximum distance to a hospital is 56 miles.

Per capita income was $3,114 in 1970, with 1,031 persons receiving public assistance through job creating programs. This was 2.5 percent of the county population.

Physicians (excluding Federal) are 38 in number, with a county ratio of 0.9 per 1000 population. There are 117 registered nurses, 131 licensed practical nurses, and 3 licensed physical therapists in the county.

There are two general hospitals and two long term nursing homes in Eddy County. They are as follows:

Table II-74 Hospital and Nursing Facilities, Eddy County

General Hospital	Location	Bed Capacity
Artesia General Hospital	Artesia	51
Carlsbad Regional Medical Center	Carlsbad	127
Total		178

Long Term Hospital Units	Location	Bed Capacity
Lakeview Christian Home of the Southwest	Carlsbad	29
Landsun Homes	Carlsbad	24
Total		53

The Artesia hospital operated at an average annual occupancy of 55 percent. The five days of highest census show an occupancy rate ranging from 80 percent to 90 percent. The average length of patient stay was five days.

A non-profit organization has submitted plans for a 62-bed Intermediate Care Facility in Artesia.

At Carlsbad, the hospital average annual occupancy was 68 percent. The five days of highest census show a range in rate of occupancy of 87 percent to 91 percent. The average length of patient stay was 6.2 days.

The nursing homes operated at 102 percent annual occupancy in the skilled nursing unit.

Carlsbad Regional Medical Center has determined that further long-range planning will be beneficial before proceeding with construction projects.

(5) Lea County

Lea County's major cities are Hobbs and Lovington, with a total population in 1970 of 34,940, which was 70.5 percent of the county population and was 38.5 percent of the Study Area population. The county population is composed of 2,676 people 65 years old and over. This is 5.4 percent of the county population, and is 42 percent of the Study Area population 65 years old and over.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

The county has 4,394 square miles of rolling prairies.

The population per square mile was 11.3, and the maximum distance to a hospital is 40 miles.

Per capita income was $3,444 with 772 persons receiving public assistance through job creating programs. This was 1.6 percent of the 1970 population.

Physicians (excluding Federal) are 32, with a county ratio of 0.6 per 1000 population. There are 81 registered nurses and 1 licensed physical therapist in the county.

The New Mexico Junior College in Hobbs has an associate degree program for nurses.

There are four general hospitals located in Lea County. There are as follows:

Table II-75 Hospital and Nursing Facilities, Lea County

	General Hospital	Location	Bed Capacity
1	Eunice General Hospital	Eunice	12
2	Hobbs General Hospital	Hobbs	123
3	Jal General Hospital	Jal	30
4	Lovington General Hospital	Lovington	53
			218

General hospitals in the area operated at a cumulative average annual occupancy of 46 percent, with individual occupancies of 43%, 52%, 28%, and 44%. The five days of highest census for the hospitals ranged in rate as follows:

Table II-76 Highest Census of Hospitals

Hospital	Occupancy Rates
1	125% to 142%
2	67% to 76%
3	63% to 70%
4	60% to 87%

Average length of patient stay was as follows:

Table II-77 Average Length of Patient Stay

Hospital	Average Stay
1	4.4 days
2	5.8 days
3	4.5 days
4	5.3 days

All conforming nursing home beds in the county (two facilities) are presently operated as Intermediate Care.

(b) Social Services

Although usually conceptualized as public assistance or welfare, social services refers to a broader range of helping services. These include: adoption, homemaker or chore services, family planning, foster care, day care, home management, etc. In the Study Area, the New Mexico Department of Health and Social Services provides these services, as well as referral services in the areas of health, training, education, and housing.

Persons receiving public assistance through job creation programs totaled about 1960 in the Study Area, which is 2.2 percent of the 1974 population estimate. In 1970, the county totals were 1031 (2.5%) for Eddy and 772 (1.6%) for Lea. Eddy County increased almost 15 percent from 1970 to 1974, while Lea County's total remained about the same.

(1) Law Enforcement

This section discusses law enforcement in the Study Area, including the two county sheriff departments and the municipal police departments of the four major cities.

(a) Sheriff's Department

Each of the two counties has a sheriff's department. The jurisdictional area of each department is the entire county, including municipalities. In 1974, the total number of full-time officials employed by the two departments in the Study Area was 31. Eddy County had a total of 18 full-time officials, while Lea County had 13 full-time officials. The Study Area's ratio of full-time employees per 1000 population is .34. Eddy County's ratio is .45 while the ratio for Lea County is .26. In 1974, one full-time officer served approximately 2,929 persons and covered 251 square miles in the Study Area. In Eddy County, each full-time official served 2,244 persons and covered 233 square miles of the county, and one full-time official in Lea County covers 277 square miles and serves 3,877 persons.

TABLE II-78

Sheriff's Department
Carlsbad Potash Area, 1974

Area	Total Population	Sworn Officials	Sworn Officials per 1,000 Population	Population Served per Full-time Officer	Land Coverage per Full-time Officer (sq. mile)
Study Area	90,800	31	.34	2,929	251
Eddy Co.	40,400	18	.45	2,244	233
Lea Co.	50,400	13	.26	3,877	277

Source: Community Profiles, Department of Development, 1974-75.

(b) Municipal Police Department

The departments for the four major cities in the Study Area consist of 137 full-time policemen, providing the Study Area with 1 full-time policeman per 580 population of 1.72 officers per 1000 persons (see table below). The two major cities in Lea County have a higher ration of policemen per 1000 population than the 2 major cities in Eddy County.

TABLE II-79

Municipal Police Department
Four Major Cities, Carlsbad Potash Area, 1974

Area	Total Population (est.)	Full-time Officers	Full-time Officers per 1000 Population	Population Served per Full-time Officer
Study Area	79,510	137	1.72	580
Artesia	12,010	20	1.67	600
Carlsbad	25,000	39	1.56	642
Hobbs	33,500	58	1.73	578
Lovington	9,000	20	2.23	450

Source : Development of Development, Community Profiles, 1974-75.

(2) Fire Protection

This discussion of overall fire protection in the Study Area is based upon information supplied by the fire departments of the four major cities.

The Artesia fire department is comprised of 16 volunteers and 10 paid firemen, who operate one fire station. The department has the following equipment: 4 pumper units, 3 emergency units, and 2 other vehicles.

The fire department for Carlsbad is staffed by 22 paid firemen. The department mans 3 fire stations and maintains 12 units of equipment, including 5 pumper trucks, 3 emergency units, and 4 other vehicles.

The Hobbs fire department operates three fire stations and maintains 16 units of equipment, including 6 pumper trucks, 3 emergency vehicles and 7 other vehicles. The force consists of 41 full-time and 6 part-time firemen.

Lovington's fire department has three paid firemen and 22 volunteers. The department operates one fire station and maintains eight units of equipment, which include 5 pumper trucks, 2 emergency vehicles and 1 other vehicle.

(3) Water and Sewer

An inventory of present (1974) water and sewage systems for the four major cities in the Study Area is discussed in this section.

(a) Artesia

The City of Artesia obtains its water supply from seven water wells. The total daily capacity of the water system is 8,000,000 gallons, while the average daily consumption is 2,500,000 gallons. The peak consumption has been 8,000,000 gallons. Storage capacity of the water system is 2,000,000 gallons.

The city has a 3,000,000 gallon per day capacity Sludge Plant (Primary Secondary Treatment). The average load of the sewer system is 750,000 gallons and the peak load is 1,500,000 gallons. The plant discharge is used for irrigation. Ninety-five percent of the city is served by the sewer system. The city operates a landfill city dump. Garbage and trash collections are bi-weekly for residential, and daily for business.

(b) Carlsbad

The City of Carlsbad, like Artesia, obtains its water supply from seven wells. The total daily capacity of the water system is 22,500,000 gallons. The peak consumption has been 15,000,000 gallons, while the average daily consumption is 6,000,000 gallons. The water system has a storage capacity of 10,000,000 gallons.

Carlsbad's sewer system is a trickling filter type with a 6,000,000 gallon per day capacity. The average load is 4,000,000 gallons with a peak load of 4,700,000 gallons. The system discharges into the Pecos River. The sewer system serves 95 percent of the city.

Garbage and trash are collected daily from businesses and bi-weekly in residential areas. The city's solid waste disposal is a sanitary landfill.

(c) Hobbs

The city's water supply is obtained from 19 city owned wells. The daily capacity of the water system is 9,800,000 gallons. The average daily consumption is 5,000,000, and the peak consumption has been 7,000,000 gallons. Storage capacity for the Hobbs water system is 9,800,000 gallons. The city has a 3,100,000 gallon per day capacity secondary sludge digester sewage treatment plant. The average load of the sewer system is 2,500,000 gallons. The city maintains a sanitary landfill.

(d) Lovington

The city of Lovington gets its water supply from 11 wells. Total daily capacity of the water system is 6,480,000 gallons, with an average daily consumption of 1,206,610 gallons. The peak consumption has been 4,210,000 gallons. Storage capacity for the water system is 4,300,000 gallons.

The city's sewer system has a 1,000,000 gallon per day capacity and is a filter type plant. Average load is 450,000 gallons, while the peak load has been 600,000 gallons. The system discharges into a sewage pond. The sewer system serves 100 percent of the city. Garbage and trash collections are made daily from business and twice weekly from residential areas. The city dump is a sanitary landfill.

(4) Utilities

Major communities within the Study Area receive utility service of natural gas, telephone, and electricity from Southern Union Gas, Hobbs Gas Supply, General Telephone, Mountain Bell, Southwestern Public Service, Central Valley Electric, and New Mexico Electric. Visits and telephone conversations with various city officials in the Study Area and Southern Union Gas indicate that current and future consumer demands for utility use and installation can be easily made without undue delay.

(5) Community Attitudes and Lifestyle

(a) Lifestyles

Historically, the Study Area has been a ranching area. The early dominance of ranching as both an economic activity and way of life has profoundly affected the economic and social structure, the value systems and attitudes - - the earlier lifestyle.

Since development of oil, gas, and potash, mineral development has been superimposed on the traditional ranching lifestyle. As economic dominance shifted from ranching to mineral development, both population and social structure were affected.

The present lifestyle is not so strongly tied to the land and to the self-sufficiency and stability, so characteristic of the earlier ranching culture. The transient nature of much of the incoming population argues against the development of strong community ties, and suggests that the ultimate lifestyle will be more impersonal and fluid, less close knit, and less stable than before.

(b) Attitudes

Closely tied to and flowing from the prevailing life-style of an area, community attitudes provide an indication of the goals and objectives of a given community. While vital to the planning and decision making process, information on community attitudes is difficult to obtain. In an attempt to get a measure of the public attitude toward land use, in the Study Area, and the public's expectations regarding the ability to pursue a desired lifestyle, the Bureau of Land Management solicited comments from various groups and organizations in the area. Responses were received from 34 groups or organizations, about one-fourth of the total requests mailed (See Socio-Economic Appendix for copy of request and response received). As this Environmental Analysis progresses through the public participation phase, additional comments concerning community attitudes will be received and incorporated.

The majority of the responses were favorable toward mineral development (potash) with respect to the economic impact. The major opinion expressed was that all factors were positive. Negative responses dealt with water and air pollution problems.

(6) Economic Characteristics

(a) Eddy County

Unlike neighboring counties, Eddy County did not depend upon government spending to bolster its economy. In 1960, only nine percent of the county's labor force, civilian and military, was on government payrolls. This percentage has continually increased in the past decade. On the other hand, 68% of Eddy's labor force received income classed as private salary and wages.

Eddy's private enterprise economy has functioned well to date. The median family income, $7,870, exceeds the State median. Perhaps its greatest weakness lies in its lack of diversification. In 1965, the value of mineral production was approximately $140,000,000; of this total, potash accounted for more than 80 percent.

The county has had a recent foretaste of the consequences of its lack of economic diversification. On July 1, 1967, one of the two largest operators in the Carlsbad Area laid off 400 employees, almost one-half of its total staff. The cost to the county in payroll is 2-1/2 million dollars annually. Apart from the immediate consequences, this is a reminder to the county and the state, that other economic bases must be found before potash reserves dwindle.

Bonded debt for the county during 1970 was zero, leaving net capacity of $6,206,000; therefore, the financial situation is generally healthy. It is worthwhile repeating that the economic base lacks diversification, and this shortcoming must be faced eventually, and that solutions to the problem are not to be found in manufacturing or processing based upon the dominant mining industry.

Between 1964 and 1970, assessed valuation increased from $145,593,000 to $155,167,000. In the period of 1965 to 1970, bank deposits grew from $46,951,000 to $87,443,000.

The work force in June 1966 was approximately 17,649 (with an unemployment rate of 6.6%). During 1970 it was at 14,862. In February 1971 unemployment was 6.4%, welfare 6.0% and 11.5% were on food stamps, in a 1970 population of 41,119 (compared to 1960 population of 50,783 or a 19.0% decrease). The migration rate for Eddy County since 1960 is 35.4 percent; much is reflected in the area of potash mining.

The majority of the employed during 1970 was 21.7% mining, 15.7% wholesale and retail and sales, 14.0% government, and 8.2% in all agriculture, and 4.3% in manufacturing.

The oil and gas industry continues to be of great importance to Eddy County's economy. In 1967, the value added by the oil and gas industry was $67,000,000, with a total for all mining of $137,500,000.

(b) Lea County

Lea County is one of the wealthiest and most productive areas in New Mexico. It accounts for nearly two-fifths of the state's total value of mineral production and for two-thirds of its production of crude petroleum. In addition, its agricultural production is well balanced and has experienced significant growth in recent years. Other activities, particularly manufacturing and services, have provided increased employment and income during the 1960's. Thus, Lea County clearly has a strong and diversified economy.

Yet during the current decade, the county's total population and employment have experienced net declines. Although the amounts are less than ten percent for both indicators, the fact remains that there were fewer residents and jobs in the county in 1970 than in 1960. The reason for these trends and their implications for the future are the primary concern of the following analysis of economic activity in the county.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

Mining alone in Lea County had value added of $316,800,000 and continues to be the leading industry. Between 1964 and 1970, assessed valuation increased from $223,690,000 to $322,411,000. Bank deposits from 1965 to 1970 reflect a variance from $54,091,000 to $100,162,000. Bonded debt was zero for 1970, leaving net capacity of $12,896,000.

During 1966, the employed work force was 20,492 (with 4.3 unemployment) and during 1970 dropped to 19,545, a relatively small decrease compared to many other areas. In February 1971, the unemployment reflected 4.2%, welfare 4.1% and 7.0% of the population was on food stamps. The county experienced a decrease in population of 7.3%; population for 1960 was 53,429 and for 1970 was 49,554. Net migration from 1960 to 1970 was 23.9%.

The major percentage employed was 23.3% mining, 18.2% wholesale and retail trade, 11.4% government, 10.5% transportation, public utilities and communications, 8.8% services, and 6.3% all agriculture.

Lea County's recent economic difficulties are directly related to problems encountered by its two basic industries, agriculture and mining. During the current decade, both of these sectors have accounted for a steadily decreasing share of the county total employment and personal income. In 1960, mining provided 29 percent and agriculture, 8 percent of all employment in the county. By 1970, only 23.2 percent of all jobs were accounted for by mining, and 6.3 percent by agriculture.

The declining employment in agriculture and mining is largely the result of technological gains and other secular changes in the National economy. Productivity gains, which have been particularly significant in these two activities, have made possible increased production with fewer workers.

In addition, reductions in exploration acitivity for new petroleum and natural gas reserves have adversely affected employment levels in the oil and gas field services sector.

The unemployment rate in Lea County is consistently lower than that of most counties in the state. Thus, fewer persons are either unemployed or living in poverty, according to the federal definition.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

The most important source of personal income in Lea County is mining, which directly provides about one-fourth of the county's overall total. Indirectly, its impact is also significant, since an important manufacturing activity is petroleum refining and many trades and services firms are dependent upon the economic strength of the mining industry in the county. The total mining income in Lea County exceeds that of any other New Mexico County.

Employment reductions by the mining industry, especially in petroleum and natural gas, seem to have resulted from rising productivity, declining exploration activities for new fields, and the rising costs of operating existing facilities. Expectations about future trends are mixed, but the experience of the past few years seems to imply that production of petroleum and natural gas will not increase significantly in the near future. A conservative prediction might be that large increases in the production of crude petroleum and natural gas are unlikely unless there are significant discoveries of new fields in the future. Declining reserves of both oil and gas seem to dictate lower production levels within a few years if new fields are not found and exploited.

(7) Summary - Economy 1974

(a) State

The economy of New Mexico in 1974 slowed down but not as much as the rest of the Nation. The sectors of the economy which suffered the greatest from the National recession were manufacturing, construction and tourist related industries.

/1/ Agriculture

The value of all crop production dropped from $203.3 million in 1973 to $183.5 million in 1974, down $19.8 million, or 10 percent. Cash receipts from all farm marketings dropped 10 percent, from $813.8 million in 1973 to $732.6 million in 1974.

/2/ Banking

Total resources of all banks in New Mexico rose from $2.8 billion in 1973 to $3.1 billion in 1974, an increase of $208 million, or 7.2 percent.

/3/ Construction

The value of construction contracts dropped from $677 million in 1973 to $615 million in 1974, a decline of $62 million, or 9 percent. Although a slowdown in construction occurred in 1974, it was still the second largest year on record.

/4/ Employment

Although the recession caused layoffs in some industries, total employment (annual average) increased from 387,604 in 1973 to 401,582 in 1974 up 13,978 or 3.6 percent. The unemployment rate rose from 5.6 percent in 1973 to 6.3 percent in 1974.

/5/ Government

Is the largest sector of employment in the state. About one-third of all wage and salary jobs are held by persons in local, state, or federal agencies. Employment in Government has increased from 99,500 in 1973 to 102,200 in 1974, up 2,700.

/6/ Personal Income

New Mexico per capita income of $4,137 in 1974 continues to lag far behind the United States figure of $5,434 - it ranks 49 out of 50 states. An encouraging sign is the increase of total personal income from $4,262 million in 1973 to $4,642 million in 1974, an increase of 8.9 percent.

/7/ Mining

The value of mineral production in 1974 rose to a record $1,934 million, an increase of 48 percent over 1973. Employment in mining took a significant jump, from 16,400 in 1973 to 19,000 in 1974, up 16 percent - the largest increase during the last ten years.

Source: New Mexico Progress 1974, Vol. XLII

(b) Study Area

/1/ Banking

Total resources of all banks in the Study Area rose from $269,935,000 in 1973 to $308,130,000 in 1974, an increase of $38,195,000 or 14 percent. Deposits climbed by 13.4 percent, or increased by $32,525,000.

Carlsbad Potash Study Area (Socio-Economic Profile Area)

Table II-80

Study Area Banks - Resources, Deposits, 1973 & 1974

Area	1973 Resources $	1973 Deposit $	1974 Resources $	1974 Deposits $
Study Area	269,935,000	242,146,000	308,130,000	274,671,000
Eddy Co.	112,541,000	101,462,000	125,163,000	112,103,000
Lea Co.	156,809,000	140,684,000	182,967,000	162,568,000

Source: New Mexico Progress, 1974, Vol. XLII.

/2/ Construction

Total building permit valuation, based on 1974 building permits in the three major cities (Carlsbad, Hobbs, Lovington) in the Study Area, amounted to $7,962,880, for a total of 196 new housing units.

Table II-81

1974 Building Permits and New Housing Units

Area	Total Building Permit Valuation	New Housing Units
Study Area	7,962,880	196
Eddy Co.	3,292,580	125
Lea Co.	4,670,880	71

/3/ Employment

Total employment in 1974 was 31,590, a decrease of 8.2 percent from the 1970 employment total of 34,407. At the same time, the unemployment rate dropped from 5.1 percent to 4.2 percent in 1974.

II-82

Covered Private and Government Employment, June 1974

Area	Agri.	Mining	Constr.	Mfg.	Trans. Comm. Util.	Trade	Finance Ins. & R. E.	Serv. & Misc.	Covered Total	Fed. State & Local	Grand Total
Study Area	107	8695	1993	1743	2803	6937	1065	4232	27,575	4015	31,590
Eddy Co.	40	3186	730	725	702	2931	442	2153	10,899	1946	12,845
Lea Co.	67	5509	1263	1018	2101	4016	623	2079	16,676	2069	18,745
(Percent-Area)	(.33%)	(27.5%)	(6.3%)	(5.5%)	(8.9%)	(20.0%)	(3.4%)	(13.4%)	(87.3%)	(12.7%)	(100.0%)

Source: New Mexico Progress 1974, Vol. XLII

II-83

1974 Estimated Civilian Labor Force, Employment, Unemployment and Unemployment Rate (Annual Average)

Area	Civilian Labor Force	Employment	Unemployment	Unemployment Rate
Study Area	38,701	37,089	1612	4.2
Eddy Co.	16,690	15,870	820	4.9
Lea Co.	22,011	21,219	792	3.6
New Mexico	428,496	401,583	26,913	6.3

Source: New Mexico Progress 1974, Vol. XLII

/4/
Government

Total employment in government decreased in the Study Area from 4302 in 1970 to 4015 in 1974. Although there was a decrease in number employed in government, the percentage increased from 12.5% to 12.7%.

/5/
Mining

The value of mineral production in the Study Area was $684,392,000, an increase of 28.7 percent over 1973, while production decreased from 2,168,000 short tons in 1973 to 2,092,000 short tons in 1974. Employment in mining increased significantly in the last four years. In 1970 employment in the mining industry was 7,777 persons, this increased to 8,695 in 1974, up 11.8 percent.

II-84 Value of Mineral Production, 1973

Area	Production (thousand $)	Minerals produced (in order of value)
Study Area		
Eddy Co.	224,195	Potassium salts, petroleum, natural gas liquids, salt, sand and gravel, stone.
Lea Co.	460,197	Petroleum, natural gas, natural gas liquids, sand and gravel, stone.

Source: New Mexico Progress 1974, Vol. XLII.

(8) Land Use Controls and Constraints

In the study area (comprised of Eddy County and Lea County), a number of separate jurisdictional entities exercise certain types of land and resources use control. The Federal sector includes the National Park Service (Carlsbad National Park), Forest Service (Lincoln National Forest), and the Bureau of Land Management (national resource lands and mineral estate under certain private lands).

Development, management, use and control of use on federal lands has been delegated to these agencies. With certain exceptions, uses and controls come under the discretionary authority of the agency head. Controls are effected through issuance or nonissuance of a variety of leases, permits, licenses, etc. Each authorization to use federal lands contains provisions to control that use. Agencies have monitoring, compliance and enforcement authority. Controls exercised by the Federal Government for the subsurface estate are governed by the statutes authorizing the disposition and use of that estate. Among these statutes would be authority for leasing potash deposits and authority to require, as a condition of such leases, a mining plan and a reclamation plan. Management policy has been extended in more detail by the National Environmental Policy Act of 1969. In certain situations, there is a joint or multiagency sharing of particular management and control functions and responsibilities. The subsurface estate vested in private or state ownership would normally be governed by applicable State of New Mexico Statutes.

A number of state agencies have development and administrative authority over state owned lands. Additionally, under State of New Mexico Statutes, counties and municipalities have been delegated authority to perform and administer certain surface land use planning and development activities on state, county, municipal, and privately-owned properties. Control does not apply to federal properties, except as provided by law. Except where controls have specifically been delegated by statutes to counties or municipalities, the State retains total jurisdiction over public (nonfederal) lands. Certain of these lands were conveyed to the state as a part of the Act admitting New Mexico to the Union (37 Stat. 1723, 1-6-1912). Under a Territorial Grant (30 Stat. 484, 6-21-68), sections 16 and 36 of every township were granted to the State for educational purposes. In addition, the

State Grants Act of June 20, 1910 (36 Stat. 557) granted sections 2 and 32 to the State, also for educational purposes. Use and control of these lands (including mineral leasing, rights-of-way, etc.) is governed by New Mexico law and administered under State Statutes by the State Land Commissioner.

Under New Mexico Statutes, counties have authority to effect a wide variety of controls in matters not specifically reserved to the State. The authority applies only to those portions of the county outside municipal limits. A county may regulate and restrict location and use of buildings and structures and use, condition of use, or occupancy of lands for various purposes. The authority does not apply to any planning and zoning control over lands used or occupied for the extraction or production of minerals. New Mexico law defines counties planning jurisdiction to include lands over three miles from the limit of a municipality having a population of less than twenty-five thousand, or five miles form a municipality having a population of twenty-five thousand or more. Less than one percent of the lands in the two county study area are owned by county governments. Use and control of these lands would be governed by state law and county ordinances.

In summary, all of the respective jurisdictions (federal, state, and counties) have sufficient authority to impose effective land and resource use controls. The real problem is the commitment of the appropriate governmental entity to exercise these authorities under the laws.

E. LAND USE COMPATIBILITY AND SUITABILITY

This section of the Environmental Analysis Record is designed to ensure consideration of the interrelationships between the proposed action and alternatives and all other existing and potential uses of lands adjacent to the Study Area. However, because the potash industry draws physical support (i.e. electric power, water, natural gas, etc.) from outside of the Study Area additional interrelationships on other than adjacent lands have been identified. As these interrelationships have similar characteristics to those within the Study Area, a discussion of them is included in this section

1. Oil and Gas Leasing

On initial observation, all of the land uses within the Study Area and on adjacent lands appear to be compatible with one another and with the proposed action. Closer investigation bears this observation out with one notable exception. There are several points of incompatibility between the potash industry, including the proposed action, and the oil and gas industry. Potash and oil and gas are all leasable minerals for which leases are issued by both the BLM and the State of New Mexico. (See Map I-1 in the back pocket of this report to understand the overlapping between existing oil and gas leases and existing potash leases and applications.) Deposits of all three of these minerals resources exist within the Study Area. This fact byitself poses no particular problems or incompatibilities. It is in the exploration and production phases that the problem arises. For reasons of mining safety and the structural integrity of oil or gas drill holes, first mining of potash ores is not permitted within a 250 foot radius of a producing oil or gas well and second mining is prohibited within an additional radius equal to the distance from the surface to the top of the ore zone. This results in the effective loss of varying tonnages of potash ores depending on the depth to the potash ore zone. At a depth of 2000 feet, the loss of ore is in the neighborhood of two million tons. For these same reasons, an oil or gas well cannot be drilled through a mined potash ore zone until such time as the entire mine complex involved has been abandoned. To date no oil or gas wells have been drilled through abandoned potash mines. In attempting to assure minimum loss of resource values and minimum delays in development of both the potash and oil and gas reserves the Secretary of the Interior and the State of New Mexico have established special policies for the potash/oil and gas interface area.

The Secretary of Interior's Order of October 18, 1951, as amended by the Secretary's Order of May 11, 1965, established what is known as the potash area withdrawal. This withdrawal concerns oil/gas and potash leasing within the withdrawn area, situated in Eddy and Lea Counties, New Mexico.

Within the withdrawal area, on federal lands and/or mineral reserves, no oil and gas wells will be drilled except upon approval of the Area Oil and Gas Supervisor, U. S. Geological Survey. Drilling will not be permitted if it interferes with the mining and recovery of potash deposits. Also no wells will be drilled for oil and gas at a location which would result in undue waste of potash deposits.

The order also provides that no mining or exploration operations for potash will be conducted if such would constitute a hazard to oil and gas production or would unreasonably interfere with the orderly development and production under any oil or gas lease issued for the same land.

In administering this withdrawal, the Area Oil and Gas Suprvisor, USGS, takes into consideration recommendations of the Area Mining Supervisor, USGS, and applicable conservation rules and regulations of the Oil Conservation Commission of the State of New Mexico.

On March 1, 1974, Acting Secretary of the Interior John C. Whitaker approved certain recommendations contained in the Chief, Conservation Division's (USGS) memorandum of February 14, 1974 (Appendix D-3).

The memorandum reaffirms the Department's position that the Secretarial Order of May 1965 adequately protects the rights of the oil and gas and potash industries. Briefly, major considerations recommend and now in effect are:

(1) The potash area withdrawal is being expanded to include known potash deposits in T. 22 S., R. 31 E.; T. 23 S., Rs. 29 and 31 E.; and T. 24 S., Rs. 30 and 31 E., NMPM, presently outside the designated area.

(2) Potash lessees have been required to furnish USGS considerable information concerning mineable ore deposits and mined out areas. This information is to be up-dated annually.

(3) Vertical or directional drilling for oil and gas will now be allowed in certain closed areas. Three year mining plans may be required of potash lessees.

(4) Oil and gas lease unitization will be encouraged to reduce the number of wells drilled.

(5) The Department reaffirms cooperation with the New Mexico Oil Conservation Commission particularly on well locations within the State of New Mexico's "Oil Potash Area" as that area is delineated by NMOCC Order No. R-111, as amended. The Department of Interior reasserts its prerogative to render final decisions affecting federal oil and gas leases.

(6) Unresolvable controversies which cannot be dealt with in the field will be referred to the Chief, Conservation Division, USGS, with a recommendation from the Regional Conservation Manager. The State land ownership is mostly made up of small scattered tracts, intermingled with federal and some private owned tracts.

In certain cases, where potash ore reserves are found on small State tracts, it becomes imperative to develop the potash reserves on the adjoining federal land at the same time. Development of State and federal potash must, therefore, work hand-in-hand in order to establish logical and economic mining units.

Development of oil and gas reserves on State lands can affect development of federal potash ore reserves. For instance, development of an oil or gas well on a State tract may also drain an oil or gas reserve on adjacent federal lands. This drainage could result in another producing well on federal land as a well on federal land may be necessary to pump the federal oil or gas rather than to allow the oil or gas to be drained laterally by wells on State lands. If this federal tract also contained a potash ore reserve, development of the potash would thus be delayed.

Conversely, if potash reserves were developed on a federal tract, this could preclude immediate development of an oil and gas reserve on an adjacent State tract.

On July 10, 1951 the New Mexico Oil Conservation Commission created Order No. R-111 and an oil potash area known as R-111A. The objective of this order was to prevent waste, protect correlative rights, assure maximum conservation of oil and gas resources in New Mexico and permit simultaneous economic recovery of potash minerals in the area defined. The R-111A area covers the area of known potash ore reserves in southeast New Mexico. See Appendix D-3 for a copy of this order and the map of the area involved.

If conflicts cannot be settled directly between lessees the Oil Conservation Commission acts as arbitrator. The arbitration considers resources and does not consider land ownership. During the arbitration the Commission decides whether potash or oil and gas will be developed first on a particular area.

2. ERDA (The Energy Research and Development Administration) - Atomic Waste

The Energy Research and Development Administration, (ERDA), formerly the Atomic Energy Commission, has been seeking ways to dispose of radioactive wastes for some time.

Today atomic waste resulting from nuclear weapons development is all stored in the nation on surface sites. However, within several years, radioactive wastes from nuclear plants will be produced in abundance, and therefore there is a need to find a suitable, and safe storage method.

Preliminary studies have indicated that bedded salt formations provide one of the safest storage areas and southeast New Mexico was selected as having many of the desirable site factors. The nuclear waste management storage facility would be established approximately 28 miles east of Carlsbad, New Mexico, in Eddy County. The area under consideration involves portions of Townships 21 and 22 South, Ranges 31 and 32 East, (see Map I-1).

The underground area east of Carlsbad in Eddy County is especially advantageous because of its salt beds which are about 2,000 feet deep and 500 to 1,000 feet thick. The reason that salt beds appear to be advantageous is that there is no water in the region. So the storage area for such waste could be absolutely dry, thereby reducing the risk of contamination carried by water.

Sandia Labs at Albuquerque is currently doing a study for ERDA. The scope of this project is for Sandia Labs to provide conceptual design for intermediate and low level waste storage. High level waste would not be included in the initial project, although research concerning high level waste storage would be carried on in these areas.

If studies and nuclear waste disposal pilot operations prove favorable, the long term use of the ERDA project area could be permanently [and totally] dedicated to atomic waste storage. ? This ~~would~~ could eliminate potash mining and all other subsurface land uses from 33 square miles of the potash study area.

Presently, the Bureau of Land Management, at the request of ERDA, has placed a moratorium on all mineral leasing of United States lands within the proposed site of ERDA's atomic waste disposal project. The Bureau of Land Management has given ERDA permission for the construction of access roads and the drilling of test holes, solely for gathering preliminary physical information on the area.

The exploratory drilling underway at this time will determine the most suitable location for storing the waste material in the area.

The actual objective of the study and testing is to get a pilot plant in operation to find out whether or not this method of storage will work. The target date for beginning construction of such a pilot operation is late 1978 or late 1979. Actual storage of waste material could begin in 1981 if all goes according to plan.

Stored wastes ~~will~~ would consist of those being produced by ERDA and by commercial reactors. At the pilot plant stage, wastes would be handled retrievably and experiments and measurements would be undertaken that could lead to the pilot plant being converted into a full scale depository for the permanent disposal of these wastes. Initially, only alpha contaminated low level radioactive wastes ~~will~~ would be stored (i.e., wastes whose external radiation is low enough not to require remote handling techniques). Later, intermediate level wastes ~~will~~ would be added to the pilot plant operation, and still later, high level wastes.

The waste disposal study area is within the area of known potash ore deposits. At this time it is not known what all the relationships or interrelationships might be between ERDA's atomic waste proposal and the potash industry. About all that is known is than an undetermined amount of potash ore in the waste disposal Study Area ~~will~~ would be irretrievable during the period of the ERDA study. If the study proves successful, an undetermined amount of potash ore will be lost.

The atomic waste disposal project is the subject of an Environmental Impact Statement presently being prepared by ERDA, and public comments will be solicited by that agency.

3. Bureau of Land Management Grazing Leases

In the potash Study Area there are approximately 716,728 acres of national resource lands under license for the grazing of cattle and sheep. This is the predominant surface land use in the Study Area. There are 43 licensees or private ranch operations dependent on federal lands for grazing. The complete listing of BLM grazing licensees and their allotments is included in Appendix E-2. These operators have been allotted certain areas of National Resource Lands which they use in conjunction with lands leased from the State of New Mexico and private lands for their cattle and/or sheep operations.

The potash operations do take some land out of production that could otherwise by used for grazing of livestock. However, there is only one federal grazing allotment that is significantly affected (T. Bingham): about 20 percent of this allotment is affected by brine waters. Overall, the cumulative effects are minimal for the entire Study Area.

The potash industry provides water to a number of grazing allottees from the Caprock water lines and through the development of some wells. This is a benefit to the livestock operators and to the government because it results in improved water availability for wildlife and livestock, resulting in better livestock distribution and management.

In summary, the BLM grazing operations and the potash leasing operations are compatible within the potash Study Area.

4. Water Rights and Uses

All surface and ground water in New Mexico is publically owned. The "beneficial use" is a basis and limit of the right to use water. Water rights are basin property rights and there are no preferential uses. All water users, including the potash companies, obtain their water rights through the same procedures.

For declared underground water basins and for surface waters, the procedures are basically the same. Applications for new water rights are filed with the State

Engineer. Applications are normally approved if the applicant can show: (1) there is unappropriated water available, and (2) that this water can be taken without impairment of existing water rights.

All the underground water in the Study Area is within declared water basins. This means that before anyone can use water from the area, a license to do so must be granted by the State Engineer. Therefore, any future appropriations of water within the Study Area will be by license issued by the State Engineer, on a non-preferential, basic property right basis.

5. Private Industry

There are 3 major companies, near Carlsbad, New Mexico whose operations relate to the potash industry: Becker Industries Corporation, N-Ren Southwest, Inc., and United Salt Company. Becker Industries and N-Ren Southwest are new chemical manufacturing operations, with facilities now under construction. Both of these companies facilities will use significant amounts of electricity, natural gas, and water. This indicates an increasing demand for the supporting resources from industrial users other than the potash industry. In the event of future shortages, allocations of these resources will be made in accordance with priority systems established by the State of New Mexico.

Both Eddy and Lea Counties have a low unemployment rate (see Socio-Economic Section, page II-259). Therefore, since the potash industry also has plans for new production facilities, the two companies mentioned above will be competing with the potash companies for the available labor force.

United Salt Company located about 15 miles southeast of Carlsbad, is a third major company whose operations relate to the potash industry. United Salt uses some waste salt from the potash refineries, but very little in proportion to the total amount produced by the refineries. Most of United's raw salt comes from Laguna Grande De La Sal, otherwise known as Laguna Grande or Salt Lake. No information is available from United Salt Company pertaining to the use of water, electricity, and natural gas.

There is a possibility of another salt company being established in the Carlsbad area, but there are no definite plans or information available at this time.

6. Rights of Way

There are numerous pipelines, transmission and distribution powerlines, communication lines, country roads, highways, and other rights-of-way land uses in the Study Area. Support facilities for potash lease development alone, requires over 900 acres of rights-of-way land use. These rights-of-way are compatible with the other land uses in the area with the exception of aesthetics and cultural resources.

7. Wildlife

Wildlife land use is suitable on approximately 963.406 acres in the Study Area. The potash industry exclusive use acreage (6.469 acres) is the only use not compatible with wildlife use. Under the existing situation, wildlife land use is compatible with Potash lease development on a regional basis. Potash lease development provides improved vehicle access which may subject wildlife to increased disturbance by increased vehicle traffic. Over the past several years there has been an increase in the size of the lakes in lower Nash Draw. Possibly due to the raising of the acquifer level by the addition of potash effluents, this increase in lakesize has been beneficial for waterfowl and shorebirds.

The exclusive use areas such as those used for refinery sites, tailings piles, and brine ponds are not suitable for wildlife use because of the complete destruction of habitat for all species of wildlife.

8. Aesthetics and Recreation

Approximately 963,406 acres of land surface in the Study Area are suitable for recreational land use. The exclusive use of 6,469 acres for potash lease development is the only land use not compatible with recreational land use, however recreational land use is compatible with all other existing and proposed land uses.

Recreational opportunities which exist within the Study Area can be pursued equally well over the entire area rather than being restricted to a specific locality within the area (i.e. hunting and ORV use). Therefore, the incompatibility of removing lands from public use in one locality is just as significant to these activities as it would be in any other locality within the Study Area.

The aesthetic quality or visual character of the Study Area is currently one of broad open spaces intermixed with concentrations of mining and industrialization. So long as a balance between these elements can be maintained, the proposed action would be compatible with the existing visual character. Should the balance be tipped in favor of either element, an incompatibility would result. It must be remembered however, that incompatibility is not necessarily a synonym for adverse impact. Whether or not an incompatibility is an adverse impact is dependent in part on the cultural background of the observer and the degree to which the contrast is inharmonious with the overall visual character.

Based on the relative demands for recreation and aesthetics as opposed to demands for potash products from the Study Area, the proposed action would be compatible with these land uses on a regional basis so long as the aforementioned balance is not upset.

9. Cultural Resources

Except for the Potash Lease Development exclusive use area mentioned above, the entire Study Area is suitable for study and protection of the cultural values found in the area. Available data indicate that the area contains from 18,000 to 23,000 archaeological sites. The cultural values of the sites will determine the compatibility of this land use and other land uses. Where values are high, this land use is highly incompatible with other land uses. This study has resulted in two 5,000 acre proposals for National Register Districts to preserve their cultural values. In these two districts, surface disturbing land uses will be incompatible to the proposed land use.

State Grants Act of June 20, 1910 (36 Stat. 557) granted sections 2 and 32 to the State, also for educational purposes. Use and control of these lands (including mineral leasing, rights-of-way, etc.) is governed by New Mexico law and administered under State Statutes by the State Land Commissioner.

Under New Mexico Statutes, counties have authority to effect a wide variety of controls in matters not specifically reserved to the State. The authority applies only to those portions of the county outside municipal limits. A county may regulate and restrict location and use of buildings and structures and use, condition of use, or occupancy of lands for various purposes. The authority does not apply to any planning and zoning control over lands used or occupied for the extraction or production of minerals. New Mexico law defines counties planning jurisdiction to include lands over three miles from the limit of a municipality having a population of less than twenty-five thousand, or five miles form a municipality having a population of twenty-five thousand or more. Less than one percent of the lands in the two county study area are owned by county governments. Use and control of these lands would be governed by state and county ordinances.

In summary, all of the respective jurisdictions (federal, state, and counties) have sufficient authority to impose effective land and resource use controls. The real problem is the commitment of the appropriate governmental entity to exercise these authorities under the laws.

F. Existing Potash Operations

1. Environmental Description - Typical Conditions

This section of the report describes the unique aspects of the environmental settings around, and the general operations of each of the 7 existing potash refineries. The setting of each refinery is somewhat similar and the environmental conditions previously described for air, page 1, hydrology, page 168, geology, page 136, wildlife, page 203, ecological interrelationships, page ____, and land use compatibility, page 295, cover the environment of the refinery sites. Cumulative resource utilization and support facility development by the potash industry are discussed on page 351, and shown on maps II-7 (p. 169), II-23 and II-24.

Fieldwork done in making this analysis indicates that there have been alterations of soil and vegetation around each of the refineries as a result of the air emissions which were described earlier. (Standard Soil Survey, Eddy Area, 1971; Lea County, 1974; and Potash Area Soil Analysis, 1975, were consulted in all elaborations on soils.)

Soils, Vegetation

Excessive amounts of salts have accumulated under the tailings piles and brine disposal areas of the potash refineries. This has rendered that soil area sterile. Vegetation is completely destroyed under the salt tailings piles in the brine disposal areas and for 10 to 25 feet around the edges of these areas. The fenced refinery sites are barren of vegetation and remain in that condition because of excessive salt in the soil. Vegetation would probably have to be kept out of these areas for safety reasons even if the salt content of the soil were not excessive.

In general, the vegetation in close proximity to the fenced refinery area has been changed completely because of the salt accumulations in the soil. Salt levels are greater in the shallow more loamy soils than in the deep sandy soils. In all directions away from the refinery site, salt accumulations in the active root zones decrease to the levels of typical conditions found outside the site specific area of each potash refinery. At the point where salt accumulations cease to be found in the active root zone, no visual effects can be seen in the vegetation. The distance from the potash refinery to areas where salt accumulations in the soil decrease, varies for each refinery site depending upon the prevailing wind direction, topography, soil type precipitation, etc.

Soil samples were collected at all the individual potash refinery sites. Line grafts depicting chemical analyses values for sodium, potassium, calcium, magnesium, and total salts ($ECX10^3$) corrulated to distances from the refineries are shown in Appendix A-10. One examole is illustrated and explained in the narrative of the area around the AMAX refinery.

2. Mississippi Chemical Corporation (MCC)

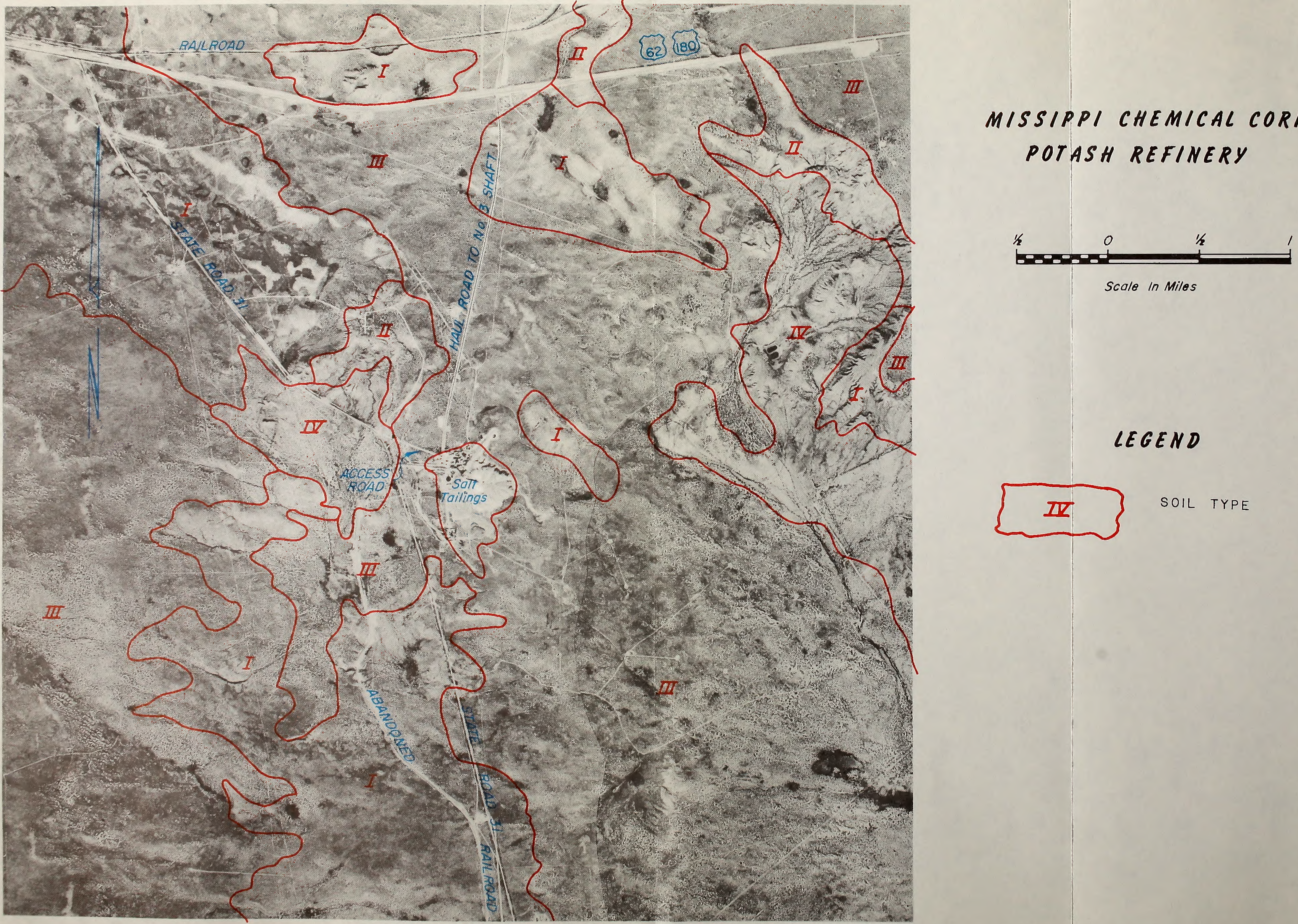
a. Mining

Mississippi Chemical Corporation currently produces an average of 100,000 tons of potash per year; however, this is greatly below desired production due to temporary modifications of the refining facilities for the treatment of lower quality ore. One level is mined at 850 feet by conventional full-face advance mining with electric drill jumbos, loading machines and shuttle cars, while continuous miners are used for development work. Rock bolting provides ground support, with main ore haulage by conveyor belts. The production shaft supplies intake ventilation (139,000 cfm), while the service shaft is for exhaust.

b. Refining

Mississippi Chemical Corporation processes 2,400 tons per day (tpd) sylvite ore, containing about 4 percent clay by flotation as shown in Figure I-12, p. I-42. About 400 tons KCl is made daily, equivalent to average annual production of 120,000 tons KCl. Brine and solid tailings discarded daily contain the equivalent of 2,000 tons NaCl and other salts. Electric energy consumption is estimated at about 90 kW-hr per ton of product. Natural gas and fresh water use per ton of product are respectively, 0.5 Mcf, and about 2,000 gallons. About 90 percent of the fresh water entering the refinery is discarded in the form of brine that contains in percent; 0.6 K, 2.8 Na, 0.01 Mg, 0.1 Ca, 3.2 Cl, and 0.3 SO_4.

MCC dry crushes the ore to minus 3/8 inch, then grinds wet in a rod mill to minus 6 mesh. Thickened slimes from the desliming circuit are discarded without washing.



MISSIPPI CHEMICAL CORP. POTASH REFINERY

Map II-16

c. Environmental Description (See Map II-16)

(1) (2) Topography, Drainage

MCC's existing refinery site is on a slope positioned between the dunelike topography of the uplands and the broken, lower elevations, which are dominated by a karst topography. The drainage from the area flows into Nash Draw.

(3) Soils

The soils occuring around MCC are typical of the entire Study Area. Cacique, Potter-Simona and Simona-Bippus soil series of Group I, Stony Rough Broken land of Group II, Kermit-Berino, Pajarito soil series of Group III and Largo soil series of Group IV occur here. The Cacique soil series is most prominent around the site, while smaller areas of Potter-Simona and Simona-Bippus do occur. Cacique soil typically have an indurated caliche layer, from 12 to 36 inches deep. The caliche layer is located at a depth which would indicate a possibility of salt accumulation in the soils. Chemical analysis of these soils in the vicinity of the MCC refinery indicate salt levels which are not considered detrimental to vegetation. The soils are found on nearly level to gently sloping positions of the landscape. Permeabiltity is rapid at the surface, but moderate at depth. Water holding capacity of these soils is moderately low, and they are susceptible to severe wind erosion if the vegetative cover is depleted. Hummocks of sand, 1 to 3 feet high are common, and the surface layer has typically been altered by wind erosion. Water erosion is a lesser problem because precipitation soaks into the profile rather rapidly. Adapted vegetation is established in the area. The Potter-Simona and Simona-Bippus soil series typically have indurated layers at 9 to 19 inches depth. Visible vegetative deterioration attributable to salt accumulations is difficult to distinguish in the vicinity of the MCC Refinery.

Widely scattered, small areas of Stony Rough Broken land occur on slopes to steep ridges and breaks. These soils are thin bedded, indurated to weakly cemented caliche, overlying fractured, weakly cemented layers in thickness from a few inches to 20 inches in depth, near the base of slopes. The surface layer texture, when located at the top of slopes, is gravelly loam. On the side slopes, cobblestone and stones are mixed with very shallow, loamy soil material. V-shaped gullies are common. Surface runoff is rapid and the soil material is washed away nearly as fast as it forms. Revegetation is difficult because of the impervious layer at shallow depth, and the limited amount of soil present.

Kermit-Berino and Pajarito soil series occur as large areas of land around the Mississippi Chemical Refinery. They are weakly calcareous to noncalcareous, well-drained sands. They have developed in wind worked materials and alluvium derived from sandy sediments of the uplands. The surface is undulating and billowy with stabilized dunes from 3 to 15 feet high. Permeability is very rapid and water holding capacity is low. These soils are extremely eroded by wind and water erosion when protective vegetative cover is depleted. Soils are difficult to revegetate, as rainfall is undependable and surface water is lacking, except after infrequent, intense rains. No sign of restrictive salt zone is evident in these soils and the area is well vegetated.

Largo soil series found in the area consist of deep, loamy, calcareous soils. They are gently sloping, having developed from upland sedimentary materials. These soils have slight erosion by water, with V-shaped gullies common in drainage ways. Permeability is moderate while water holding capacity of the soils is high. Vegetation must be maintained to control erosion. Normal precipitation has leached salts which would have been detrimental to vegetation from the active roots zone. Salt tolerant plants are established, but visible vegetative deterioration attributable to salt accumulations is hard to detect.

(4) Vegetation

The major native perennial grasses around the MCC refinery are dropseed, three awn and stipas; hooded windmill grasses exist around the salt tailings pile and brine pond of this refinery site. Annuals such as spectacle pod and western ragweed are present. Major shrubs are creosote brush, mesquite, yucca and sandsage. There does not appear to be any affected vegetation beyond the refinery site, tailings piles and brine ponds.

(5) Aesthetics and Recreation

The existing MCC refinery site is located immediately adjacent to, and on the east side of New Mexico State Highway 31, south of U. S. Highway 62/180 and north of the IMC facilities. The surrounding lands are steeper and slightly more rugged than those surrounding the facilities of the other potash companies. Even at that, the color variation between soils, rock and vegetation is so slight and the views so confined as to make the immediate vicinity of the refinery a scenically very uninteresting area. However, if one moves from a half to three quarters of a mile to the east, a view of Nash Draw and the brilliant red Maroon Cliffs open to view.

This area offers recreational opportunities similar to those found in the rest of the Study Area for hunting and hiking. Some opportunities for off-road vehicle use also exist in this area.

(6) Archaeology

The present refinery site was not closely investigated for cultural values; however, some statement can be made because of the location of the refinery site. Located on Nash Draw, looking across at the Maroon Cliffs area, the refinery lies within a dune ridge which contains high cultural values. It is quite probable that a number of sites were destroyed in the process of refinery construction, and that others have been indirectly affected because of increased access.

3. Potash Company of America (PCA)

a. Mining

The Potash Company of America produces about 550,000 tons of potash per year by continuous mining on one level (1000 feet). Ore loading is accomplished by electric loading machines with portable (piggy back) conveyors that carry the ore to a panel conveyor that feeds the main haulage conveyor belt. No shuttle cars are involved, and ground support is furnished by rock bolting. There are two shafts, one production and one service, and 300,000 cfm of air is supplied to the mine.

b. Refining

Potash Company of America processes 9,000 tpd sylvite ore which generally contains 1 percent clay by flotation and recrystallization as shown in Figure I-12, p. I-42. About 2,800 tons KCl is made daily, equivalent to average annual production of 860,000 tons KCl (550,000 tons K_2O). Brine and solid tailings discarded daily contain the equivalent of 6,000 tons of NaCl and other salts. Electrical energy, natural gas and fresh water use per ton of product are respectively 98 kW-hr, 2.75 Mcf, and 480 gallons. About 90 percent of the fresh water entering the refinery is discarded in the form of brine that contains in percent: 1.3 K, 3 Na, 0.1 Mg, 0.2 Ca, 6 Cl, and 0.4 SO_4. About 1,800,000 gallons of brine (650 gallons per ton of product) are recycled daily from the tailings pond for use in flushing solid salt tailings to waste.

PCA also manufactures assorted potassium chemicals from the white KCl made by crystallizing solution from leaching thickened slimes. Brine is evaporated in Ozarks as required to maintain a solution balance in the refinery. NaCl that precipitates on evaporation of solution is discarded. Caustic soda (NaOH) is used for pH (acidity) control in the evaporators. Minus 65-mesh fines from sizing of the dried flotation products are dissolved and recrystallized to make KCl for chemical use.

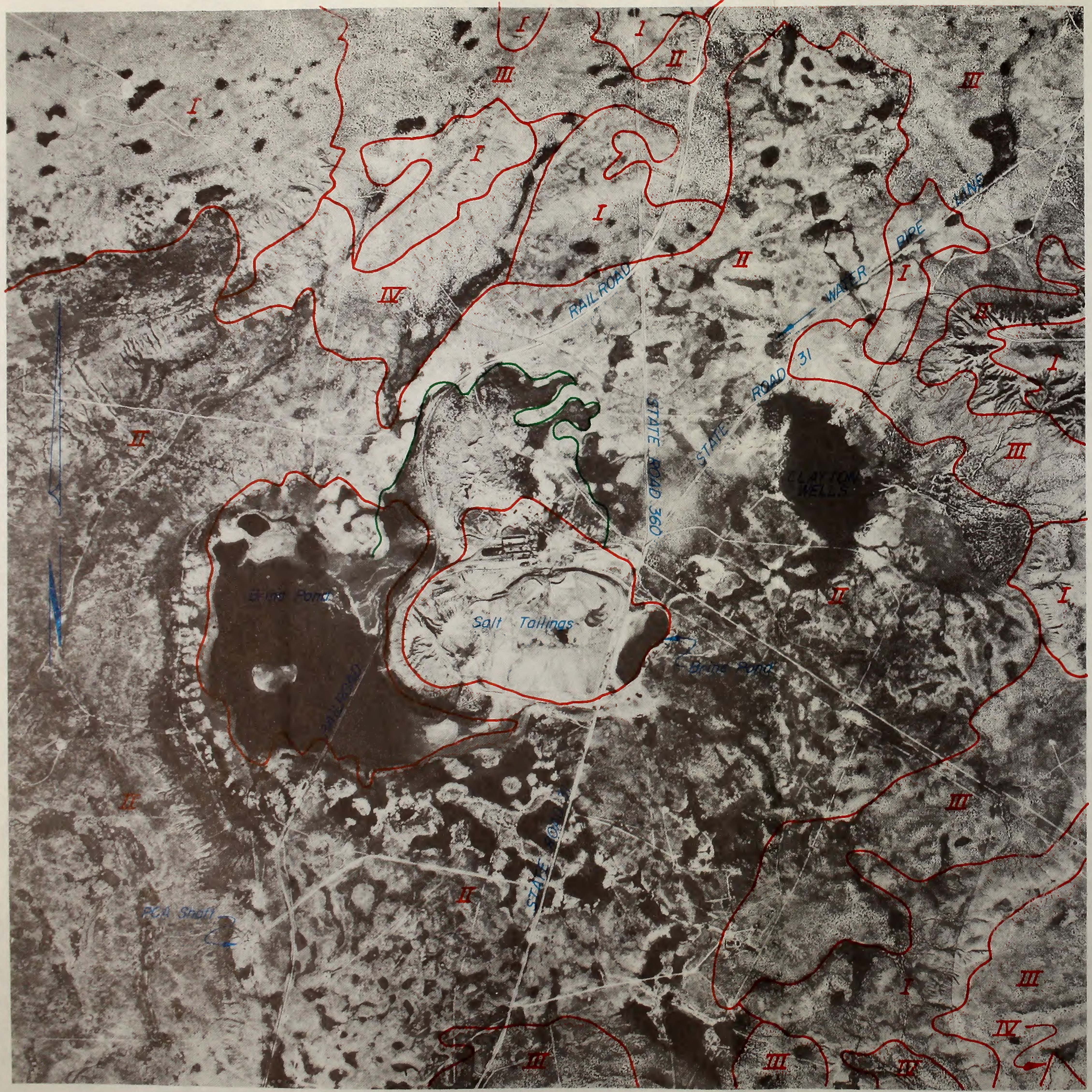
c. Environmental Description (See Map II-17)

(1) (2) Topography, Drainage

The Potash Company of America operations are located on a slope and ridge of the undulating uplands, but much of the operations are encompassed in a sink area. The drainage from this refinery flows into Clayton Basin.

(3) Soils

The dominant soil series around the PCA site is Reeves-Gypsum land complex, with large areas of Gypsum land also present. They consist of well drained, calcareous soils that are shallow or very shallow, over beds of gypsum or alabaster. Gypsum in these soils is typically encountered at 9 inches depth or less. The gypsiferous materials range from white, chalky earths to hard, light colored crystalline gypsum rocks. There are limited pockets of soil material as much as 10 inches thick, found in these areas. Fine to coarse gypsum materials are common on the surface of barren areas. They may be found on the landscape, ranging from gentle slopes to steep exposures. Surface runoff from these soils is rapid to very rapid, and the soils are subject to severe erosion if the vegetative cover is lost. The surface layer is moderately permeable, with the underlying gypsiferous



POTASH CO. OF AMERICA REFINERY

½ 0 ½ 1

Scale In Miles

LEGEND

IV SOIL TYPE

VEGETATION IMPACT AREA

Map II-17

material being slowly permeable. The water holding capacity of the soils is low to very low, and they tend to be saline and droughty. The surface crusts excessively upon drying, and the plant roots are restricted by the salinity of the underlying gypsiferous material, so revegetation is extremely difficult. The existing properties of the soils, as well as the accumulation of additional salts collecting on the surface, are indicated by the chemical analyses. They indicate salt levels detrimental to vegetation, or highly restrictive to adapted vegetation. This condition is reflected out to a distance of 3/4 of a mile in all directions from the refinery. These soils are found in Group II Soil Series.

Within the site specific area around PCA, and at some distance from the refinery there are Tonuco and Potter Simona, complex soil series of Group I, Kermit-Berino soil series of Group III, and Largo soil series of Group IV. These are identified as small, scattered areas less significant than the Group II soils.

Tonuco and Potter-Simona are soils which are typically shallow over caliche. Tonuco soils are located on 0 - 3 percent slopes (nearly level to gently sloping) and are subject to severe wind erosion if vegetation is severely depleted. Caliche blowouts are common and hummocks of sand, 1 to 3 feet high, are evident on 30 to 40 percent of the soil surface. The Potter-Simona soil series occurs on slopes of 5 to 25 percent, and is identified as small escarpments and steep breaks. The soils are moderately eroded, with exposed caliche along the tops of breaks. On the more level slopes, these shallow soils have slow runoff; while on the steeper slopes they have medium to rapid runoff. A restrictive layer at 24 inches is detrimental to the root zone of vegetation. These soils typically have an indurated caliche layer at 9 to 19 inches depth, thus creating a condition for salt accumulation within the active root zone.

The Kermit-Berino soil series is deep and sandy, having developed in wind worked material of mixed origin. The soils are typically gently sloping and undulating, with coppiced dunes. Overall permeability is moderately rapid, being greater in the surface layer than at depth. Roots are able to penetrate to 60 inches, or to the zone of lime accumulation. These soils are very susceptible to continued wind and water erosion if vegetative cover is severely depleted. This continued erosion often removes the surface layer, causing vegetation to be sparse or absent. These soils are generally leached out by normal precipitation, but erosion continues to be a problem.

The Largo soil series represent a small area at the PCA site. They are deep, calcareous loamy soils, most generally located on the landscape as gently sloping alluvial fans. These soils are eroded by water if vegetation is depleted, with deep V shaped gullies present in drainage ways. Permeability is moderate and water holding capacity is high. Depending on the texture of the subsoil, some salt accumulation may result from slower permeability rates and existing precipitation.

(4) Vegetation

Varying degrees of detrimental effects on vegetation are evident in all the soils at distances greater than the 3/4 mile from the PCA refinery. These detrimental effects are influenced by wind direction, topographic relief, etc., so influencing factors can not be separated for this study.

The PCA refinery is located within gyp soils, which are exposed to the surface throughout most of the area. Therefore, only salt tolerant plants are growing in the immediate area. There is a ridge which lies in a northerly direction from the refinery, which now has only four winged saltbush growing in an appreciable amount. This ridge appears to be the Rustler Formation, and geologic erosion is active. Therefore, there was probably little if any vegetation growing in the area originally. The gyp soils to the east of this ridge appear to have dead plant crowns appearing at random and at very sparse density. It appears these gyp soils may have had some of the surface soils removed to approximately a 2" depth. Based on these conclusions, species such as gyp grama and ring muhly have been killed out on these soils.

Four winged saltbush is surviving in many of these areas, particularly west of the refinery, and young seedlings are numerous. Alkali sacaton, hooded windmill and two-flower trichloris grasses are surviving in the area.

(5) Aesthetics and Recreation

The PCA mine and refinery are located on the west side of New Mexico Highway 31 at its junction with New Mexico 360. As you approach the refinery on New Mexico 31 from the south, the refinery itself is not visible. PCA has stacked their salt tailings, and by so doing, have effectively blocked the refinery from view. In addition, the reddish color imparted to the tailings pile by the clay removed from the ore allows the tailings pile to blend into the sandy red bluffs which lead to the north of the refinery. Opportunities for waterfowl and upland bird hunting exist in the area surrounding this refinery.

(6) Archaeology

Archaeological reconnaissance in the vicinity of this refinery was cursory. A multiphase site with mortar holes was located north of the refinery. This has not been damaged directly as a result of potash operations, but the number of tire tracks crisscrossing the site indicate an indirect previous effect because of increased access. Other sites are suspected in the vicinity of Salt Lake, but have not as yet been identified.

4. International Minerals Corporation (IMC)

a. Mining

International Minerals and Chemical Corporation currently produces an average 800,000 tons of potash per year from three different mining levels (800,850, and 900 feet). Mining is by the conventional full-face advance method, utilizing electric drill jumbos and loading machines, shuttle cars, and conveyor belts. Rock bolting provides ground support. There are 4 shafts, 1 for production and intake ventilation and 3 for service and ventilation (1 intake and 2 exhaust) with 230,000 cfm of air being supplied to the mine.

b. Refining

IMC processes about 14,000 tons per day of sylvite, langbeinite, and mixed ores. Products are in tons per day, 800 KCl; 1,800 $K_2SO_4MgSo_4$; 500 K_2SO_4. Average annual production of all products is 800,000 tons. Brine and solid tailings discarded daily contain the equivalent of 11,000 tons of NaCl and other salts.

Electrical energy, natural gas, and fresh water use per ton of product are respectively, 110 kW-hr, 2.7 Mcf, and 1,800 gallons. About 90 percent of the fresh water entering the refinery is discarded in the form of brine that contains, in percent, 2.2 K, 8.5 Na, 0.5 Mg, 0.03 Ca, 15 Cl, and 2 SO_4.

Sylvite ore, containing about 1.2 percent clay is processed by flotation as shown in Figure I-12, p. I-42. Slimes are discarded without leaching or washing. KCl fines from product sizing are compacted to make granular size KCl, dissolved to make refinery brine or slurried for conversion to K_2SO_4 by reaction with langbeinite fines.

Langbeinite and mixed ores are processed as shown in Figure I-13, p. I-47, or as described in the text summarizing the flowsheet. Ammonia is added as needed to neutralize HCl that forms during evaporation of KCl. $MgCl_2$ brine in the submerged combustion evaporators (Ozarks). This use of ammonia may accentuate the persistent plume from the Ozark stack.

c. Environmental Description (See Map II-18)

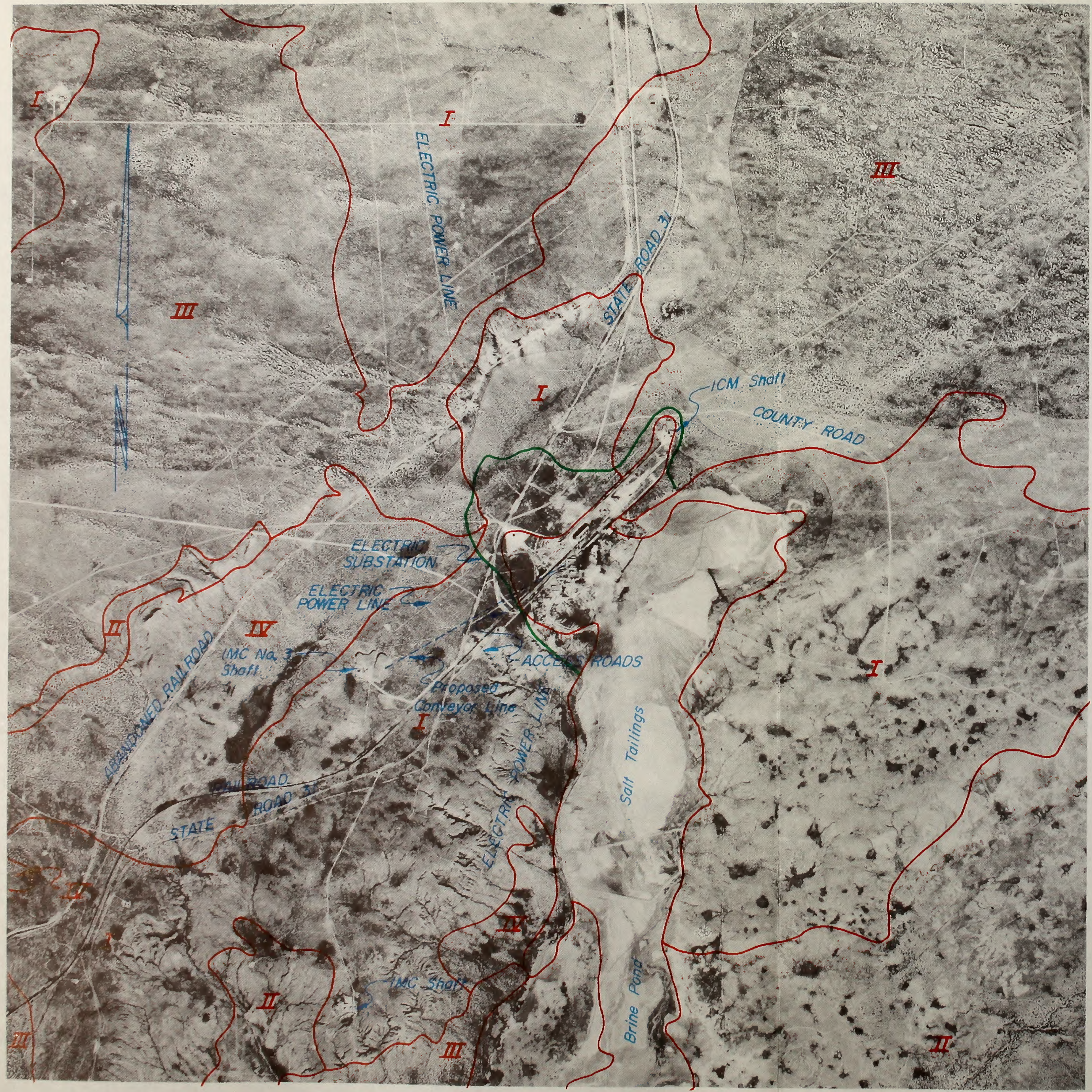
(1) Topography, Drainage

The International Minerals Corporation (IMC) operation is located in a position on the landscape between the duneland topography of the rolling uplands and escarpments, and the breaks of the lower elevations, which are dominated by a karst topography. The major drainage from the site flows into Nash Draw.

(3) Soils

Soils located around International Minerals Corporation (IMC) operations vary in depth from shallow to deep. Salts have accumulated in the soils and are indicated by the chemical analysis of the soil samples collected around the refinery site.

The Group I shallow soils found in the area are of the Potter-Simona, Tonuco, Simona-Bippus and Cacique soil series. These soils have a surface texture ranging from fine sandy loam to gravelly loam. The texture of the subsoil may vary from sandy loam to gravelly loam. They are best identified by a restrictive layer of platy, indurated caliche, which is typically found at a depth of 9 to 19 inches. Chemical analyses taken of these soils indicate salt accumulations detrimental to significant growth of vegetation up to distances of one-half mile from the refinery.



INTERNATIONAL MINERALS & CHEMICAL POTASH REFINERY

½ 0 ½ 1

Scale In Miles

LEGEND

IV SOIL TYPE

VEGETATION IMPACT AREA

Map II - 18

The deep soils located at the IMC site consist mainly of the Kermit-Berino Complex and the Berino Soil Series. They are gently sloping, undulating with coppiced dunes. The surface texture is sand, with more loamy sand occurring in the subsoil, generally below 36 inches depth. Overall permeability of the soil is moderately rapid. Permeability is rapid in the surface layer and moderate in the subsoil. Runoff is slow, with water intake being rapid. The surface layer has a low water holding capacity. Roots are able to penetrate to a depth of 60 inches or more to the layer of lime accumulation. Hummocky, dune-like topography is characteristic of the soils. They are subject to continuing water and wind erosion if vegetative cover is seriously depleted. Where this erosion has created the coppiced dunes, the surface layer has been removed, and vegetation is sparse or absent. Water movement is not appreciably restricted in these soils, and chemical analysiis of samples indicated that salts are generally being leached down through the profile to depths dictated by normal precipitation of the area. However, some high salt levels were indicated on the surface soils, up to about 3/8 mile distance from the refinery. Detrimental effects of varying degrees occur beyond these limits and are influenced by topography, climatic conditions, etc. The soil does not restrict the movement of water through the profile, but if normal precipitation is not adequate to leach the salts from the surface to below the active root zone, the salts may collect on the surface, or at shallow depths, thus restricting normal vegetative growth. These sandy soils are identified as Group III, and dominate much of the area around IMC.

A small area of deep loamy soils of the Likes series occurs west of IMC. The surface is billowy and moderately eroded, with hills and gullies being common. Typically, they have a surface layer of loamy fine sand about 12 inches thick. The underlying material to a depth of 60 inches or more, is loamy fine sand enriched by calcium carbonates. These soils are highly susceptible to wind and water erosion if vegetative cover is depleted. Runoff from adjoining lands is rapid. Permeability and water intake are rapid, but water holding capacity is low. Surface water is lacking, except for brief periods after infrequent heavy rains. Roots are able to penetrate to 60 inches or more, or to the depth of the calcium carbonate layer. Unless normal precipitation is insufficient to leach any salt accumulating on the surface, the active root zone should be leached free of salt and conducive to good vegetative growth of most species. These soils are identified as Group IV.

(4) Vegetation

The vegetation affected around the IMC operations to the largest degree, lies within one half mile of the refinery in all directions. However, it appears to extend outward in a northwest direction further than any other.

Within approximately one quarter mile of the refinery emission stack, all vegetation native to the area is dead, and the present ground cover consists of highly salt tolerant, unidentified weed species which form a dense ground cover at this time.

Progressing outward away from the refinery, the effect of the salts becomes progressively less until only certain plants appear to be affected. Within the one quarter to one half mile area, the vegetative communities appear to be changing from the original communities to a salt tolerant community. Hooded windmill and two-flower trichloris appear to be the perennial grasses which are dominant in the saltier areas, and there is a gradual change in the outward direction to plains bristlegrass and mesa dropseed community. The shrubs in this area, in general, are not dead, but appear to be kept defoliated throughout most of the year. The shrubs involved are: Little leaf sumac, greythorn, all thorn, mesquite, catclaw and creosote bush. Many of these plants show the effect of defoliation on the side facing the refinery; and the opposite side of the bush will have leafage which does not appear to be showing any affected parts, (See Photo II-16) while on others, the outside portion of the leaf may be partially dead.

In these areas, four-winged saltbush appears to be growing in an extremely healthy condition, is reproducing very well and appears to be taking over as the dominant shrub within the area.

Beyond the previously described area, the perennial grasses do not appear to show any visual affects; however, there are some shrubs which are not growing in a normal condition. These are catclaw, javelina bush and creosote bush. These shrubs are confined to shallow soils in the area.

Javelina bush and creosote are considered as evergreens (i.e., they have leafage year-round even though it may not be the same leaf), while catclaw is not. These plants, because of the soil depths, are located generally on the

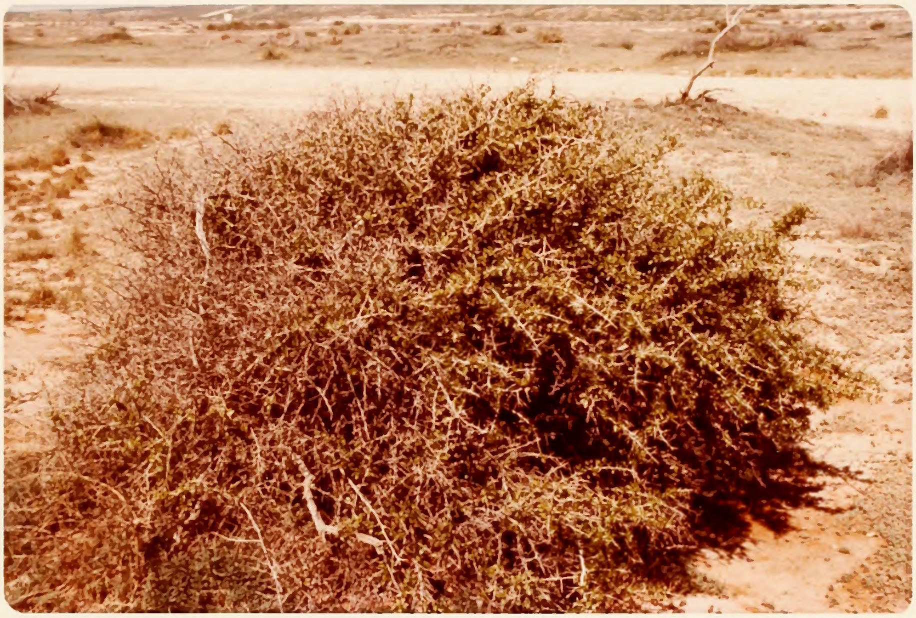


PHOTO II-16 Vegetation with partial defoliation in vicinity of International Minerals Corporation.

ridge tops. The plants are only partially defoliated, and in many cases, only the side facing the refinery appear to be affected. In some cases the catclaw, while blossoming in unaffected areas, appears to be just breaking leaf buds in affected areas, so that it appears to be approximately a month behind the growth stage on unaffected plants. This affect disappears about a mile from the refinery.

(5) Aesthetics and Recreation

The IMC refinery is located on the west side of Nash Draw on New Mexico State Highway 31, between U. S. Highways 62/180 and New Mexico State Highway 128. The view from this location to the northeast is probably the most spectacular vista occurring within the Study Area. Looking across the rugged mountains of Nash Draw, the eye is immediately drawn to the vivid red colored Maroon Cliffs. Looking to the southwest from this location, along Nash Draw, one can see several "sinks" in the Draw and the waters of Salt Lake. These views are, on occasion, blocked out by the plume emitted from the Ozark dryers used at the IMC operations.

Recreation opportunities on the lands surrounding the IMC refinery site consists of hunting for predators, small game and upland birds, hiking and picnicking in Nash Draw and off-road vehicle use in Nash Draw.

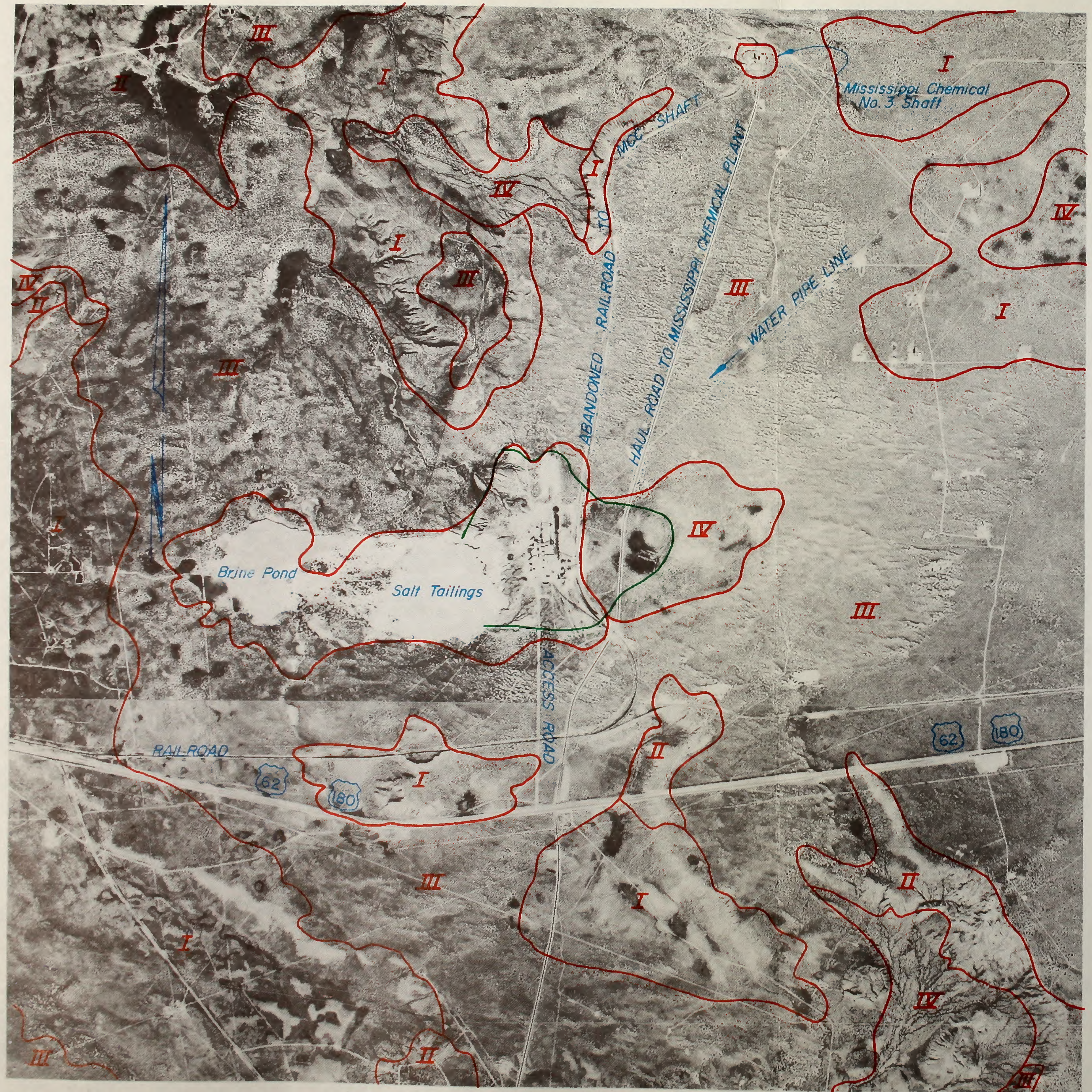
(6) Cultural Resources

The cultural resources around IMC's refinery range in age from Archaic through Ochoa Phase Mogollon and tend to concentrate in the sand dunes along the edge of Nash Draw. Construction of the refinery undoubtedly destroyed a number of the sites. Disturbed sites are found along the perimeters of the refinery, including a Hueco-Querecho Phase site north of the refinery. This particular site has been cut by a road, a fence and the power line. It is also likely that the salt tailings pile and the brine ponds below IMC in Nash Draw have covered cultural values.

5. Duval Chemical Corporation

a. Mining

The Nash Draw Mine of Duval Corporation produces approximately 674,000 tons of potash per year from two levels (900



DUVAL CORP. POTASH REFINERY

LEGEND

IV	SOIL TYPE
	VEGETATION IMPACT AREA

Map II-19

and 1070 feet) using the conventional full-face advance method of mining with electric drill jumbos, loading machines, and shuttle cars. Rock bolting furnishes ground support while conveyor belts transport the ore from the working areas to the shaft loading pocket. Two shafts supply production and service hoisting and intake and exhaust ventilation respectively (250,000 cfm).

b. Refining

Duval processes 4,000 tpd sylvite ore and 3,000 tpd langbeinite ore. Products are in tons per day; 600 KCl, 1,000 K-Mag Sulphate, and 300 K_2SO_4. Average annual production of all products is 675,000 tons. Brine and solid tailings discarded daily contain the equivalent of 5,000 tons of NaCl and other salts. Electrical energy, natural gas, and fresh water use per ton of product are respectively, 80 kW-hr, 1.4 Mcf, and 980 gallons. About 90 percent of the fresh water entering the refinery is discarded in the form of brine that contains, in percent, 2.5 K, 7.5 Na, 0.9 Mg, 0.1 Ca, 14 Cl, and 3.4 SO_4.

Sylvite ore containing 4 to 5 percent clay is processed by flotation and recrystallization generally, as shown in Figure I-12, p. 42. The dry crushed plus 10-mesh ore is further ground in a rod mill to about 14 mesh, then deslimed and the potash floated. Slime slurry is thickened, washed, and leached by heating to prepare feed solution for the KCl crystallizer. Langbeinite ore is processed as shown in Figure I-13.

c. Environmental Description (See Map II-19)

(1) (2) Topography, Drainage

The operations of Duval Chemical Corporation are located on a higher part of the upland landscape. Duneland topography dominates much of the surrounding area with escarpments and breaks interspersed. The drainage from the site flows into Clayton Basin.

(3) Soils

Soils located around Duval are typical of the Study Area, with deep sands dominating much of the landscape.

The Kermit-Berino soil series, which encompasses much of the area around Duval, represents these deep sandy soils of Group II. They are characterized by a gently sloping, hummocky, coppiced, dune-like topography. They have developed in wind worked material of mixed origin, which overlies alluvial, and sandy calcareous sediments. Sand dominates the surface texture, with occasional loamy sand found below 36 inches depth. Overall permeability of the soils is moderately rapid. The surface layer has rapid permeability and a low water holding capacity. Roots are able to penetrate to 60 inches or more, or to the layer of lime accumulation. If vegetative growth is seriously depleted, wind and water erosion continues to occur. Where erosion takes place in and around the dunes, the surface layer has been removed. Normal precipitation generally leaches the salts to a depth below most of the active root zone. Where precipitation is inadequate to leach the salts sufficiently, or where a more loamy layer is encountered, an accumulation of salts may occur. In the deep sandy soils, south of the refinery, at a distance of one quarter of a mile, chemical analyses indicate that salts seem to be leaching adequately in the profile. In the sandy soils, which occur at greater than the one half mile north of the refinery, vegetation is restricted to adapted species. Detrimental effects from salt accumulations may occur at distances greater than those already identified. Much of the Duval refinery's air emission is falling on existing tailings piles and is not reflected in detrimental effects on vegetation.

A small area of Simona-Bippus soil series is located south of the refinery, where indurated caliche is encountered at 14 inches depth. Fragmented caliche is found on the surface, and blowouts where caliche is exposed are common and typical for these soils. The soils are nearly level to gently sloping, and are generally well drained. Surface texture varies from fine sandy loam to gravelly loam, generally being 2 to 7 inches in depth. The subsoil ranges from 2 to 17 inches in depth, with texture varying from sandy loam to gravelly loam. The soils with more loam in the profile are uneroded or slightly eroded, whereas, the more sandy soils are subject to severe wind erosion, if vegetative cover is depleted. Surface run-off is slow and water holding capacity is low.

Chemical analyses of these Simona-Bippus soils indicate levels of salts in an amount detrimental to vegetative growth up to distances of 3/8 mile from the refinery. Some vegetation may be impaired in varying degrees at distances greater than 3/8 mile because of salt accumulations still present in the soils. A restrictive indurated caliche layer at 24 inches or less restricts movement of soil water, creating a condition for salt accumulation in the soil profile, with consequent restriction of the active root zone. In these soils the restrictive caliche layer is typically encountered from 9 to 19 inches depth.

Other small areas of Simona-Bippus, as well as Potter-Simona and Tonuco soil series are found in the area around the refinery site. All possess the characteristic restrictions as identified above for these Group I soils. The Duval refinery is located on these shallow soils. Detrimental effects on soils are reflected in vegetation found to the northwest of the refinery. These are influenced by the air emissions, topography, weather conditions, refinery, etc.

An area of Reagan soil series occurs directly east and adjacent to the Duval refinery and in a few discontinuous, small areas around the refinery site. These consist of deep, well drained calcareous loams that developed in old alluvium derived from calcareous sedimentary rocks. They are nearly level to gently sloping. Typically, the surface layer is sandy loam, with the subsoil varying from sandy loam to clay loam. Permeability of these soils is moderate, with runoff being slow to medium. Water intake into the soil is medium, with water holding capacity being medium to high. Roots are able to penetrate to a depth of 20 to 60 inches, or to the strong lime zone. These soils are generally uneroded or slightly eroded. Good management is required to maintain adequate plant cover and to control erosion. Slight surface crusting impedes emergence of seedlings in areas where high lime zone is exposed.

Chemical analysis of the Reagan soils indicates a buildup of salt in the profile which is detrimental to vegetation within a distance of one half mile. Varying degrees of loam in the profile may create a restrictive layer which slows the downward movement of salt in the soil. This, coupled with the ever present strong lime zone found in these soils, creates a condition which leads to excessive salt accumulation. The Reagan soils are in Group IV.

(4) Vegetation

There is only a relatively small area of affected vegetation around this refinery. The major reason is that the tailings piles lie in a westerly to northwesterly direction from the refinery, which allows the settling of the stack emissions on the tailings and brine pond area. There is a small, severely affected area immediately to the east side of the refinery. The native perennials such as mesquite, mesa dropseed and plains bristlegrass have been killed in the area for some 1,300 feet from the refinery, and have been replaced with an excellent stand of four-wing saltbush, and hooded windmill grasses. There are two drainage problem areas around this refinery which affect vegetation. The first is the drainage which starts on the south side of the refinery area and runs under the railroad tracks to the east and drains an area between the tracks. This drainage runs during the time following rainfall, which flushes surface salts out of the refinery area to the east and eventually causes them to enter an earthen reservoir. This drainage problem has resulted in a kill of all vegetation of about a 25 to 35 feet wide area for its entire length of about 1/2 mile.

The second drainage leaves the refining area in a northerly direction and eventually turns in a westerly direction. Water was running in this drainage each time the refinery was visited in April and in June. It is not the result of flood water occurrence. This drainage is in a well defined drain and disappears into the deep sand. This situation will kill the vegetation along the course if it continues to flow.

(5) Aesthetics and Recreation

The Duval refinery site is located on the north side of, and immediately adjacent to U. S. 62/180. The refinery site is surrounded by yellowish colored sand dunes, and the site itself sits atop one of the small rolling hills in this area and is therefore, highly visible to travelers along the highway. The plume from Duval's Ozark evaporators is also highly visible along this stretch of highway, and on occasion decreases driver visibility in this area. In the eyes of some, the refinery and head frame add visual interest to this area of flat to gently rolling open land. Recreational opportunities available on the land surrounding the Duval refinery site are hunting, off-road vehicle use and hiking.

(6) Archaeology

Duval's refinery is located on the east bank of an old playa, which is currently being used as a tailings pile and brine pond. The old playa was extensively utilized by prehistoric peoples, and archaeological sites ring it. Those to the east have been totally destroyed by the construction of the refinery, while those to the north have been damaged in various ways. A number of them have been bulldozed and have been used in the present dike system to control the brine waters. Others have been inundated by the brine pond itself. Some have been damaged by the new road constructed to improve access to the old U. S. Potash #3 shaft, and some have been hurt by the recent clearing of the area around the old bunkers. To the south, a large multiphase site has been cut by both the railroad which serves Duval and by the access road for that railroad. To the west, sites have been damaged and some destroyed by the support facilities for Duval and by improved access to collectors. In the case of the site damaged by the new road, the company is being required to salvage what remains in the area of the two burials bulldozed during construction.

6. AMAX Chemical Corporation

a. Mining

The AMAX Chemical Corporation has an average annual production of 700,000 tons of potash. One level is mined (800-850 feet) with the conventional full-face advance method utilizing electric drill jumbos, loading machines and shuttle cars. Ground support is by rock bolting, and main ore haulage is by conveyor belts. There is 1 production shaft and 1 service shaft; however, only the service shaft is used for ventilation (23,000-260,000 cfm), having 2 separate compartments for intake and exhaust.

b. Refining

AMAX Chemical Corporation processes 10,000 tpd sylvite ore containing 1.7 percent clay and 4 to 5 percent carnallite ($KCl.MgCl_2\ 6H_2O$) by flotation as shown in Figure I-12. About 2,200 tons KCl is made daily, equivalent to average annual production of 700,000 tons KCl. Brine and solid tailings discarded daily contain the equivalent of 7,800 tons NaCl and other salts. Electrical energy, natural gas, and fresh water use per ton of product are respectively, 75 kW-hr, 0.6 Mcf, and 950 gallons. Over 90 percent of the fresh water entering the refinery is discarded in the form of brine that contains in percent, 1.8 K, 9 Na, 0.4 Mg, 0.1 Ca, 16 Cl, and 04. SO_4.

AMAX pumps some brackish water from the Rustler Formation to assist in flushing the flotation tailings to waste. Plus 65-mesh fines from sizing the dried flotation product are compacted and flaked to make granular size KCl for market. The minus 65-mesh fines are dissolved to make KCl brine that is used in leaching residual NaCl from the cleaned flotation concentrate.

c. Environmental Description (See Map II-20)

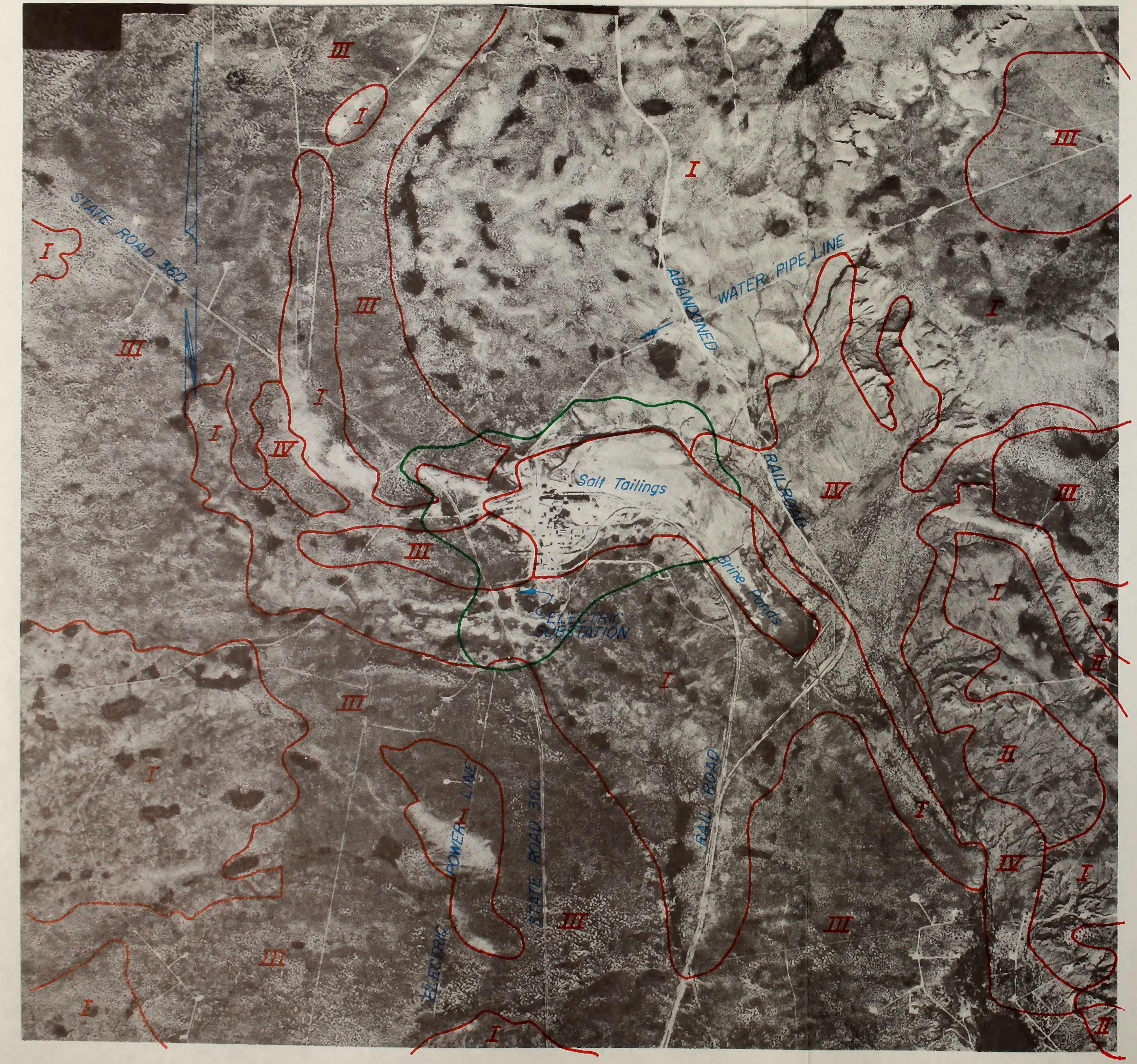
(1) (2) Topography, Drainage

The rolling, undulating uplands dominate the landscape around AMAX Chemical Corporation's operations. The site is located on the dune-like topography of the uplands, in or near breaks and escarpments, to lower lying lands. Drainage from this area flows into Clayton Basin.

(3) Soils

Soils occurring around the AMAX facility are Simona-Bippus, Potter-Simona, and Stony Rockland soil series of Group I, Berino soils series of Group III, and Largo and Likes soil series of Group IV.

Simona-Bippus soils occur as large areas around the refinery. These soils typically have an indurated caliche layer at depths of 9 to 19 inches. An impermeable layer in the soil profile at 24 inches is considered restrictive to normal vegetative growth because of its influencing soil water movement, and the creation of a zone for salt accumulation. These soils occupy a position on the landscape of being nearly level to gently sloping. They are moderately coarse textured, well drained and calcareous. If vegetative cover is depleted, they are subject to severe wind erosion. Surface runoff tends to be slow; permeability is moderately rapid, and water holding capacity is low with nearly all precipitation soaking into the soil. They are productive if moisture is available, but surface water is generally lacking except for brief periods after infrequent rains. These shallow soils have a restricted root zone, with salt accumulation zone occurring above the indurated caliche layer. Soil



AMAX CHEMICAL POTASH REFINERY

½ 0 ½ 1

Scale In Miles

LEGEND

IV SOIL TYPE

🟩 VEGETATION IMPACT AREA

Map II-20

analysis near the AMAX Refinery in this soil series indicates salt accumulations in the soil that are detrimental to most vegetation, and/or highly restrictive and only suitable for adapted species at distances of 1/2 mile and beyond. Small areas of Potter-Simona soils, with associated Stony Rockland also occur throughout the refinery vicinity. They are shallow, occurring on steeper topographic positions, and are more susceptible to greater forces of wind and water erosion. Good management is required to maintain plant cover adequate to control erosion. Varied detrimental effects from refinery air emissions are visible in the vegetation to distances of beyond 1/2 mile from the refinery.

Large areas of Berino soils are found in this Study Area. They are deep, sandy and non-calcareous soils, which have been worked by wind. They occur as gently sloping, undulating to hummocky areas. They are subject to continuing wind and water erosion if vegetative cover is depleted. When the surface vegetation is depleted, revegetation is difficult, as normal precipitation is undependable. Permeability is rapid in the surface layer, but because of higher clay content at depth, the subsoil has a moderately slow permeability rate. This zone tends to accumulate salts under normal precipitation. Chemical analysis indicates that these soils have accumulated salt in an amount to impede vegetative growth to a distance of 3/8 mile from the refinery.

Largo and Likes soil series occur as small discontinuous areas around the AMAX refinery. They are deep, loamy soils, which are gently sloping and somewhat excessively drained. They have developed in deep alluvial and colluvial materials derived from upland sediments, and they are highly susceptible to wind and water erosion. Rills, gullies and low hummocks of sand are common. Runoff from adjoining hills is rapid. They have high permeability rates, with a high water intake capacity. Because of limitation of normal precipitation, salt accumulates in the active root zones of these soils. Detrimental visible effects on vegetation in these soils at distances of one half mile are great, and restriction of vegetation to adapted species occurs at distances greater than one quarter mile. Varied visible effects on vegetation occur at greater distances and are influenced by factors of wind, topography, etc., and are independent of direction.

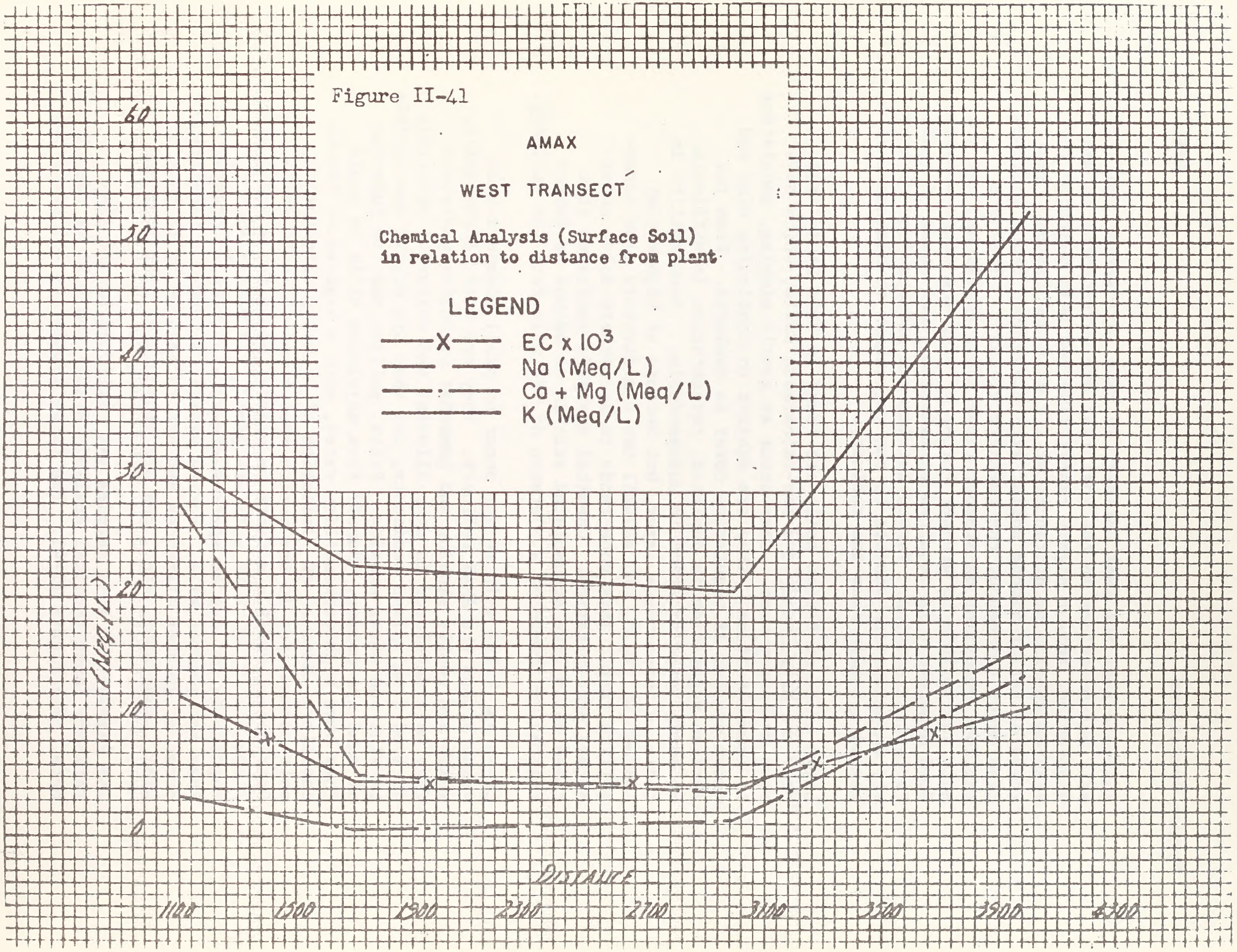
One transect of soil samples was collected at the AMAX refinery (Amax Chemical Analysis Graph) and will be identified here. See Figure II-41. The first sample was collected 300

Figure II-41

AMAX

WEST TRANSECT

Chemical Analysis (Surface Soil) in relation to distance from plant



feet west of the laboratory, which is located on the southwest extremity of the company's fenced area. This sample is about 1,700 feet from the source of the refinery air emissions. The last sample of the transect was collected approximately 2,300 feet west of the first sample and approximately 4,000 feet from the air emission source. Four samples were collected in this transect. The first 3 samples were taken from the Berino soils series and the last from the Simona-Bippus soil series. The line graph indicates that all values of EC x 10^3 (total salts), Na, K, Ca, and Mg are at excessive levels in the soils. Visible effects on vegetation were noted in decreasing degrees of effect up to a point approximately 1,700 feet west of the refinery. The potassium level at the 1,700 feet sample remains at a level which is detrimental to vegetative growth. From 1,700 feet to a distance past 3,100 feet, they chemical levels remain the same. At the last point of the graph, the accumulated salt levels have increased again. The first three samples were in deeper, sandy soil. Excessive salts are accumulating on the soil surface to 1,700 feet distance from the refinery and normal precipitation is not capable of leaching them at the rate they accumulate. From 1,700 to 3,100 feet, the salts have not accumulated excessively, and are being successfully leached. The sample taken at a distance of 4,000 feet shows an increase in chemical levels because the sample is taken in a shallow soil which develops a salt accumulation due to inadequate leaching conditions.

Although distances, directions and degrees of damage to vegetation vary at all potash refinery sites, trends are indicated from the transect results. On all sites, the potassium (K) level is high. Total salts and/or Na, Ca, Mg, generally decrease with distance from refinery. Sandy soils are being leached in most cases by normal precipitation. Shallow soils typically have impermeable layers which are difficult to leach and therefore develop a salt accumulation. The line graphs indicate surface samples only, but the results also hold true for the subsoils.

(4) Vegetation

The severity to which the vegetation is affected around the AMAX Refinery is dependent upon distance from the refinery and the depth of soil, which appears to be equally as important.

In the deeper sands, in a westerly direction from the refinery, all vegetation is severely affected to a distance of approximately 2,000 feet. Very few nonsalt tolerant grass species exist between the refinery and approximately 1,400 feet out; from that point outward, some plains bristlegrass plants are growing; many of them have a purple cast to their leaves and do not appear completely healthy.

Beyond 2,000 feet, the grasses and annual broadleaf plants do not show any effect; however, javelina bush, creosote and sandsage do appear to be partially defoliated. This effect may be observed for a distance of approximately three-quarters of a mile from the refinery.

The shallower soils appear to be much more affected than the deeper sandy soils. At a distance of approximately 2,000 feet distance from the refinery, there is virtually no perennial vegetation growing. The mesquite brush appears to be dead in that area also. At a distance of approximately 4,000 feet, creosote bush, javelina bush and broom snakeweed appear to be affected. These are partially defoliated; the sides of the javelina bush facing the refinery are mostly defoliated, while the opposite side may not be; the creosote bush was totally defoliated during one visit in April, while in June new leaf growth had reappeared, but not in a normal order.

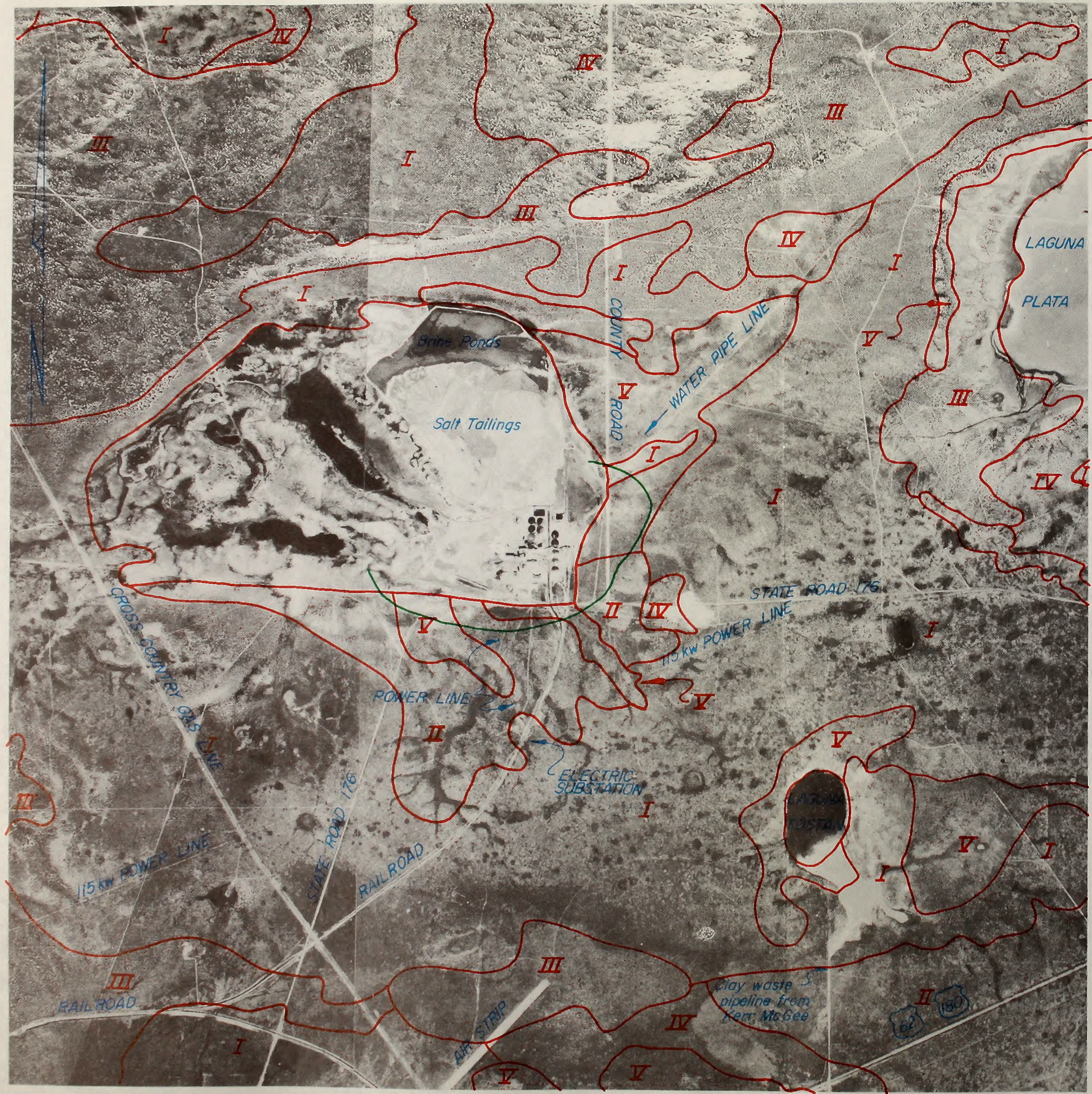
(5) Aesthetics and Recreation

The AMAX refinery site is located in an area of reddish colored sand dunes on the east side of New Mexico State Highway 360, north of the Potash Company of America operation. The refinery location is quite close to the highway, and therefore, is a significant feature of the visual landscape. The dump site located just south of the refinery has an adverse effect on the visual aspect, not only by its presence, but also by contributing wind blown debris to the surrounding lands.

Recreational opportunities for hunting, hiking and off-road vehicle use exist in the area surrounding the refinery site.

(6) Archaeology

The dune environment which surrounds AMAX, is an area of high cultural site density and has been indirectly affected through increased access. There are several Jornada Mogollon



NATIONAL POTASH CO. REFINERY

½ 0 ½ 1

Scale In Miles

LEGEND

IV SOIL TYPE

VEGETATION IMPACT AREA

Map II-21

sites east of the refinery, south of the brine ponds, and in the dunes west of the refinery. These all have been damaged by the refinery and support facilities, such as roads and power lines. It is likely that the construction of the refinery itself destroyed some cultural values.

7. National Potash Company (NPC)

a. Mining

National Potash Company Eddy County Mine produced 496,000 tons of potash in 1974. The conventional full-face advance method of mining is applied on the 690 foot level, using electric drill jumbos, loading machines and shuttle cars. Rock bolting provides ground support, and the main ore haulage is via conveyor belt. The production shaft supplies 160,000 cfm of air for intake ventilation, while the service shaft is used for exhaust. Hoisting of men and supplies is by a counterweight system.

National's Lea County Mine at the refinery site is not now in production.

b. Refining

National Potash Company processes 5,200 tpd sylvite ore containing, 1.5 percent clay by flotation and recrystallization generally, as shown in Figure I-12. About 1,500 tons KCl is made daily, equivalent to an average annual production of 500,000 tons KCl. Brine and solid tailings discarded daily, contain the equivalent of 3,700 tons NaCl and other salts. Electrical energy, natural gas, and fresh water use per ton of product are respectively, 82 kW-hr, 1.1 Mcf, and 813 gallons. About 75 percent of the fresh water entering the refinery is discarded in the form of brine that contains, in percent, 1.5 K, 4.7 Na, 0.2 Mg, 0.1 Ca, 9 Cl, and 0.5 SO_4.

Two rotary, gas-fired ore dryers are available for predrying the ore in wet weather to facilitate crushing. One of the dryers is equipped with a wet scrubber to remove particulates from the stack gas.

c. Environmental Description (See Map II-21)

(1) (2) Topography, Drainage

National Potash Company is located on a nearly level to gently rolling position of the uplands. It is somewhat unique from other potash operations, in that it is located in a sink. Severe surface drainage problems are present, as the major drainage of the area goes into Williams Sink where the refinery is located.

(3) Soils

The soils occurring around the NPC refinery are complex, but typical of the Study Area. The Simona, Tonuco soil series of Group I, Reeves-Gypsum soil series of Group II, Kermit-Polomas, Pyote, and Berino soil series of Group III and, Midessa-Wink soil series of Group V are all found in the vicinity of the National Potash Company refinery.

The Simona-Tonuco soils are well drained, calcareous and moderately coarse to coarse textured. They comprise much of the area around the refinery site. They have been worked by wind and are nearly level to gently sloping. Small caliche fragments are found on the surface, and these soils typically have an indurated caliche layer at 9 to 19 inches depth. An impermeable layer at 24 inches or less poses a problem for successful vegetative establishment. Chemical analysis of these soils indicates that a salt accumulation is occurring in the active root zone, out to a distance of about one quarter mile from the refinery. These salt accumulations are detrimental to vegetative growth, and the vegetation on these soils is restricted to salt adapted vegetation at distances greater than on quarter mile. The soils are subject to severe wind erosion if vegetative cover is seriously depleted. Runoff is slow, with nearly all precipitation soaking into the soil. Permeability is moderately rapid to rapid and the water holding capacity of the soil is low. Surface water is lacking except for brief periods when water collects in potholes or dry lakes.

Reeves-Gypsum series consist of well drained, calcareous soils that are typically shallow in depth over gypsiferous materials. A restrictive layer at the 24 inch depth in a soil creates a condition for affecting vegetative root zones. These soils typically have gypsum at 9 inches depth. They occur as nearly level to gently sloping terrain and are subject to severe erosion action if vegetation is absent. The gypsiferous material generally is slowly permeable, although the surface is moderately permeable. Revegetation is very difficult because the surface crusts on drying, and the rooting zone is restricted by the depth of underlying gypsum.

Chemical analysis of these soils indicates accumulations of salts in the soil at distances of a quarter mile, in values detrimental to vegetative growth. Salt adapted vegetation is present in the area. Varied detrimental effects occur at distances greater than 1/4 mile and are influenced by topography, wind, etc.

Kermit-Berino and Pyote soils occur as medium size, discontinuous areas around the refinery. They are deep, sandy soils having been worked by wind and derived from mixed origins. They are characterized by coppiced dune-like topography. Permeability is rapid at the surface and moderately permeable at depth. Roots can penetrate to 60 inches or to the zone of strong lime accumulation. If vegetation is destroyed on these soils, wind and water erosion becomes very active. Normal precipitation generally leaches salts to depths below the active root zones in these soils. Within a distance of a quarter mile of the refinery, salts tend to accumulate, with visible detrimental effects evident on vegetation. Varied detrimental affects are detected on vegetation at distances greater than a quarter mile from the refinery.

Midessa-Wink soils consist of nearly level to gently sloping calcareous, well drained soils having a loam surface and clay loam subsoil. Higher clay amounts in the subsoil may have slower permeability rates, thus creating a salt build up in the soils. Soft caliche typically occurs in this soil at depths of 20 to 39 inches. The soil is calcareous throughout. These soils occur as small, discontinuous areas in the vicinity of the refinery. Analysis indicates salt values in amounts causing detrimental affects on vegetation occur out to a distance of one quarter mile from the refinery. Salt accumulations occurring at greater distances are influenced by wind, topography, etc.

(4) Vegetation

This refinery is also located in an old playa area, as is Potash Company of America. The site has gyp soils at very shallow depths. The tailings piles and brine ponds are on the western side of the refinery so the only affected vegetation is a relatively small area to the east of the refinery.

Alkali sacaton was probably the original vegetation occurring on the soils. The original vegetation has been removed for about a quarter mile on the east side of thhe refinery and only unidentified salt tolerant weeds grow in that area. The disappearance of the perennial grasses is in part because of the refinery, but it is compounded by a livestock watering facility on the northern edge of the affected area.

(5) Aesthetics and Recreation

The National Potash Company refinery is located east of the Duval operation and north of U. S. Highway 62/180. The refinery site is just barely visible from the highway, and therefore, has very little impact on the visual quality as perceived from U. S. Highway 62/180. The refinery site is surrounded by reddish colored sand dunes and lies just to the west of Laguna Plata. Opportunities for upland bird and small game hunting, as well as off-road vehicle use are numerous in this area.

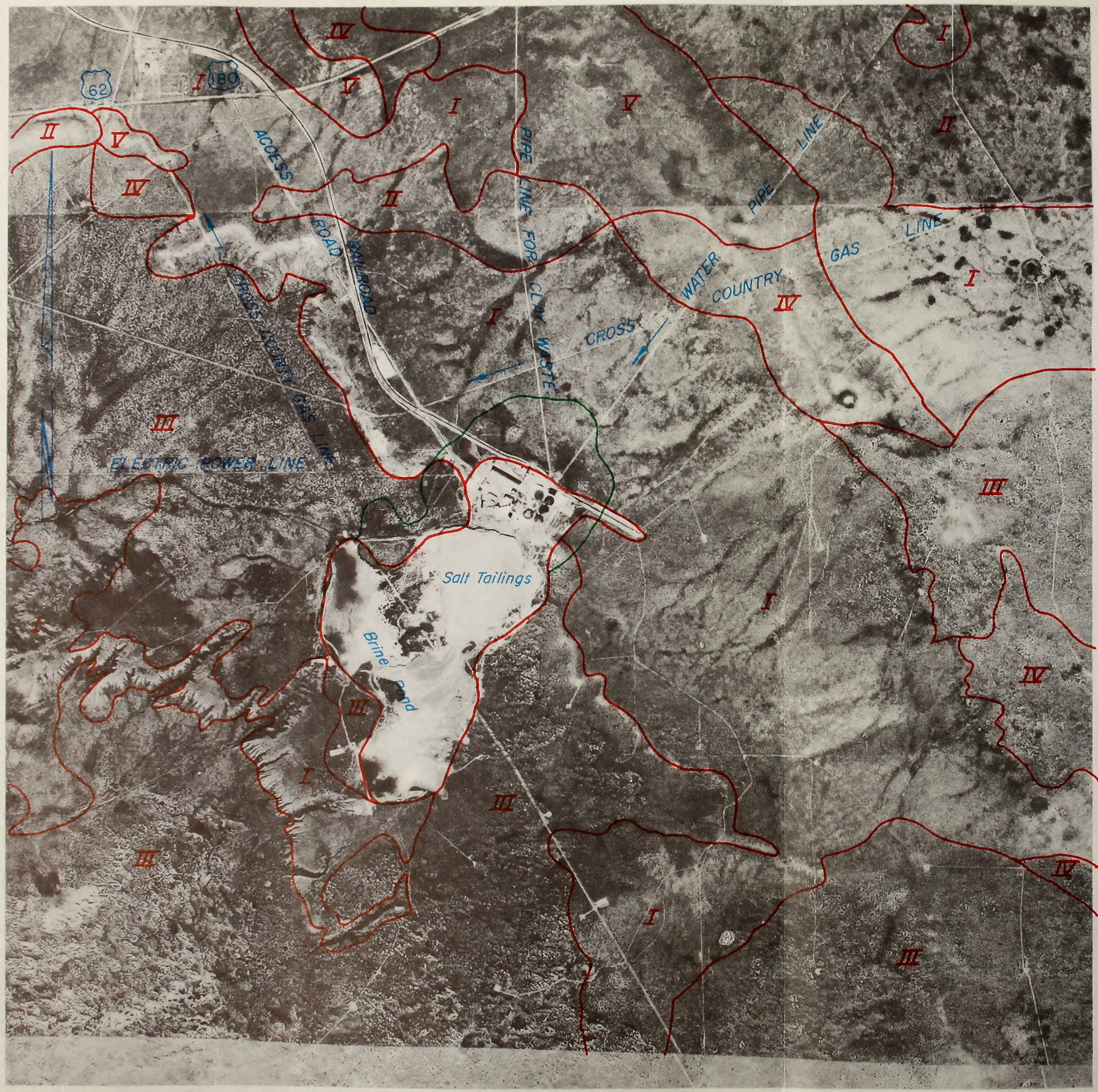
(6) Archaeology

No cultural values were observed in direct association with National's operations. A more intensive investigation may turn up such values, especially to the west of the refinery. The dunes to the north do contain cultural values which have been indirectly affected by increased accessibility. If the present salt tailings piles and/or brine pond are allowed to expand into the area of the dunes, sites will be directly affected. Support facilities such as roads which run through the dune area, have in all likelihood, damaged or destroyed cultural values.

8. Kerr-McGee Chemical Corporation

a. Mining

Kerr-McGee produces about 550,000 tons of potash per year, applying both continous (80%) and conventional full-face advance mining (20%) to extract ore from the 1620 foot level at their Hobbs Mine. Electric drill jumbos, loading machines and shuttle cars are employed, as well as the continuous miners. Ground support is furnished by rock bolting, and conveyor belts provide main ore haulage. There are two shafts, with the production shaft supplying intake ventilation (200,000 cfm) and the service shaft, exhaust. The Koepe hoist is used for production hoisting, and an unbalanced hoist system with single drum hoist is used for men and supplies.



KERR-MCGEE POTASH REFINERY

LEGEND

IV SOIL TYPE

VEGETATION IMPACT AREA

Map II- 22

b. Refining

Kerr-McGee Chemical Corporation processes 8,000 tpd sylvite ore, containing 6.5 percent clay by leaching hot KCl, washing the clay and NaCl residues, and crystallizing KCl by cooling the leach solution generally, as shown in step 7 through 13 of Figure I-12, p. 42. About 1,700 tons KCl is made daily equivalent to an average annual production of 550,000 tons KCl. Brine and solid salt tailings discarded daily, contain the equivalent of 5,800 tons of NaCl and other salts. About 500 tons of clay tailings are discarded daily; about one-third of the clay is mixed with the solid salt tailings and two-thirds is separately discarded and stored.

Electrical energy, natural gas, and fresh water use per ton of product are respectively, 125 kW-hr, 3.4 mcf, and 1,300 gallons. About 1,500 gpm of brine is recycled from the salt tailings pond for use in slurrying the solid salt tailings for pipeline discharge. The recycled brine contains in percent, 2.4 K, 8.2 Na, 0.4 Mg, 0.03 Ca, 15 Cl, and 1.4 SO_4.

Most of the fresh water entering the refineries leaves with the clay tailings and is evaporated in the brine pond.

Kerr-McGee dry crushes the ore to pass 4 mesh before hot leaching, desliming, and washing. Steam is used for pulling the vacuum that cools the leach brine in a series of agitated vessels, with resultant formation of KCl crystals. Fines from screening the dried product are compacted and fragmented to make granular size KCl for market.

c. Environmental Description (See Map II-22)

(1) (2) Topography, Drainage

The Kerr-McGee Chemical Corporation operations are located on a high position along a ridge of the uplands. The landscape of the area slopes away from the refinery site in both an easterly and westerly direction. Undulating, shallow soils are to the east, while hummocky dune like terrain lies to the west. Nash Draw receives the drainage from this operation.

(3) Soils

The soils around the Kerr-McGee facility are typical of the study area. Simona, Tonuco, Potter-Simona and Rockland soil series of Group I, Kermit-Berino, Berina Complex and Pajarito dune land soil series of Group III, and Reagan, and Wink soil series of Group IV are all found in the area. Simona and Tonuco soils comprise the bulk of the shallow soils with small, discontinous areas of Potter-Simona and Rockland soils also occurring. These are well drained calcareous, moderately coarse textured soils, which are shallow over indurated caliche. These soils are difficult to revegetate because of shallowness over caliche and the possible accumulation of salts in the soil profile. Chemical analysis indicates levels of salt in the profile to a distance of one quarter mile or more that impedes the vegetative growth and restricts vegetation to adapted species. These soils are subject to wind erosion if protective cover is depleted. Runoff from the surface is slow. Permeability is moderately rapid, while water holding capacity is low. Simona and Tonuco occur on nearly level to gently sloping topography, while Potter-Simona and Rockland are located on steep escarpments and ridges. Visible vegetation deterioration attributable to salt accumulations is found at distances of greater than 1/4 mile in these soils.

Kermit-Berino, Berino Complex and Pajarito soil series comprise the greater portion of the deep soils around the refinery. They are deep, sandy, and have developed from wind worked materials. They are gently sloping and undulating, with coppiced dune like topography. Permeability is typically rapid in surface layer and moderate in the subsoil. Surface runoff is slow, while water intake is rapid. The surface layer has a low water holding capacity. Roots are able to penetrate to 60 inches, or to the lime accumulation zone. Continuing water and wind erosion is evident, and where it proceeds uncontrolled, the surface layer has been removed with vegetation being either sparse or absent. Salt may accumulate in the active root zone if normal precipitaiton is not able to leach it down to depth. Adapted vegetation occurs on these soils.

Reagan and Wink soil series occur as small areas throughout the site specific area. They are deep loams, and generally the active root zone is not restricted to soil water movement. Some areas may have gypsum or caliche at depth beneath the loam. All these soils are nearly level to gently sloping, and are only slightly eroded. Some decrease in permeability occurs at depth in the soil, so salt accumulation may occur. Visible vegetative deterioration is found at a distance of one quarter mile on these soils. The factors of wind and topography may cause the deterioration of vegetation to extend beyond one quarter mile.

(4) Vegetation

The original vegetation around this operation was mesquite brush, black grama, mesa dropseed and plains bristlegrass. This vegetation has been badly affected in an easterly direction, having been killed out to a distance of approximately 1,400 feet and more. From approximately 1,400 feet to about 2,000 feet, black grama is dead; however, only about 50 percent of the mesa dropseed and plains bristlegrass appear to be dead, and the mesquite brush appears only defoliated.

Much of the area to the west and northwest has been disturbed for construction of the refinery railroad, power line etc. Therefore, only a small area of otherwise affected vegetation is evident in that direction, but will probably become more evident as the years go by. It is significant to note that this refinery has been in operation only about 10 years, while the other refineries have been operating much longer. Since, the area to the northwest, which has not been disturbed by construction, is on shallow soils one can expect that the vegetation in that area will become affected in time.

(5) Aesthetics and Recreation

The Kerr-McGee operations are located approximately 2 miles south of U. S. 62/180, east of Nash Draw. Two features of this operation are particularly eye catching. The first of these is the extremely large product storage warehouse with the large K M logo painted on the side facing the highway. The second is the concrete encased Koepe hoist (see Photo II-17). The Kerr-McGee refinery is the cleanest appearing of all the potash refineries in the Study Area. This is the result of the obvious lack of air borne emissions from the refining process. From the vicinity of this refinery, it is possible to get an extensive view to the south and southwest along Nash Draw.

As in most of the Study Area, opportunities for hunting and off-road vehicle use in the area around the refinery are fairly numerous.

(6) Archaeology

The Kerr-McGee refinery has had an effect on nearby cultural values, in both an indirect and direct fashion. At least one Jornada Mogollon site has been covered by the salt

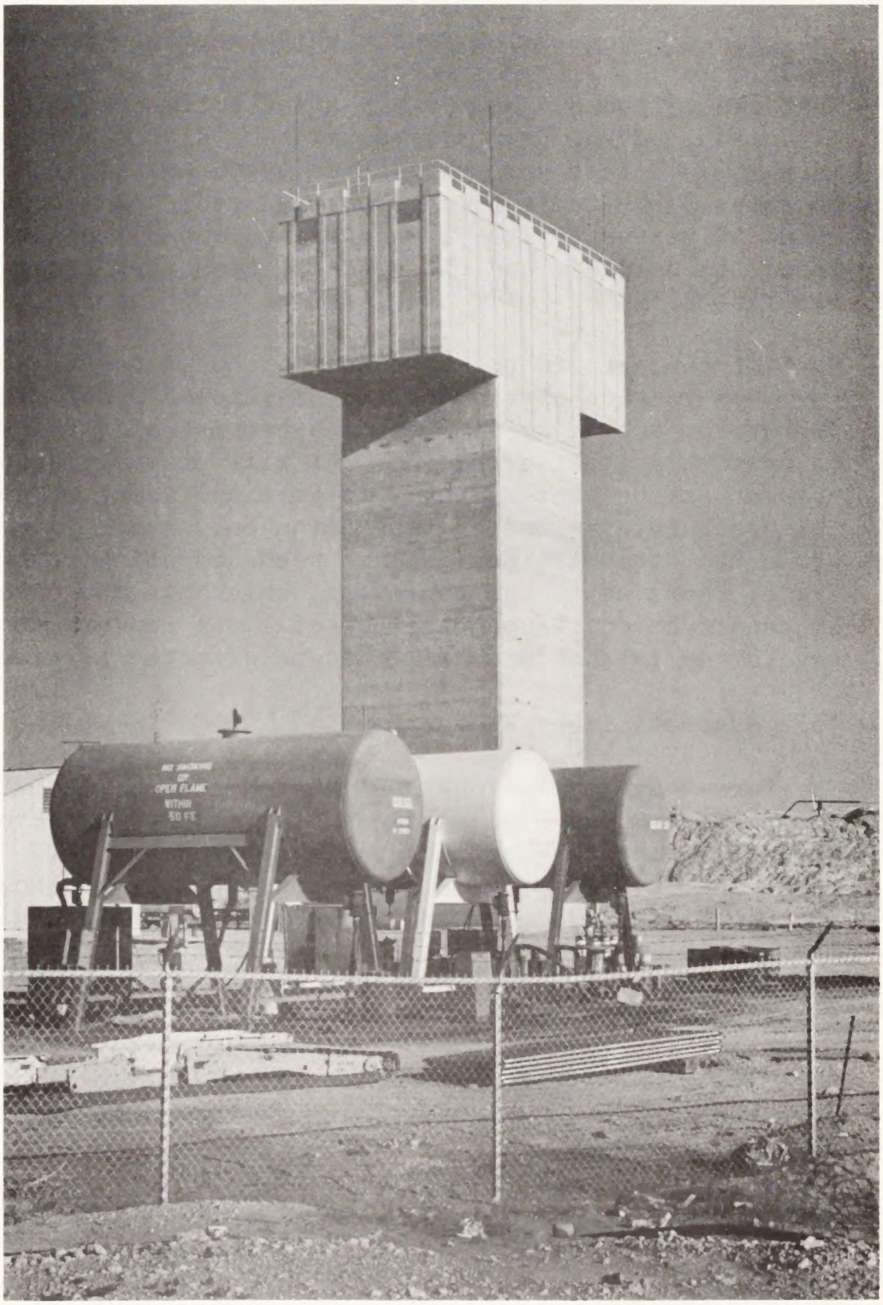


PHOTO II-17 Koepe Hoist

tailings (according to local amateurs), and a number of sites to the west have been cut by support facilities, such as power lines, roads and fences. Lack of control of brine waters and dike breakage does affect sites next to the brine holding ponds. The dunes to the south have also been indirectly damaged through increased access and visibility. The dumping of slimes into the Laguna Toston has affected 3 archaeological sites within the sink area. The rising water level has covered these sites.

9. Cumulative Support and Resource Utilization

The potash industry is a major user of electrical power, natural gas, and water in the Study Area. The highly mechanized mining methods utilize heavy duty equipment which requires large amounts of electrical power. Electrical and natural gas energy are both utilized in the refining processes which range from chemical refining by carefully controlled temperature and pressure, to mechanical separation methods. Water requirements for refining are also very high. Water is used primarily for washing, leaching and discarding tailings.

The following cumulative resource utlization by the potash industry is based on requirements for energy and water reported by the companies:

Annual Water Consumption	5,042,736,000 gallons
Annual Electrical Power Consumption	402,148,000 KWh
Annual Natural Gas Consumption	8,138,000 Mcf

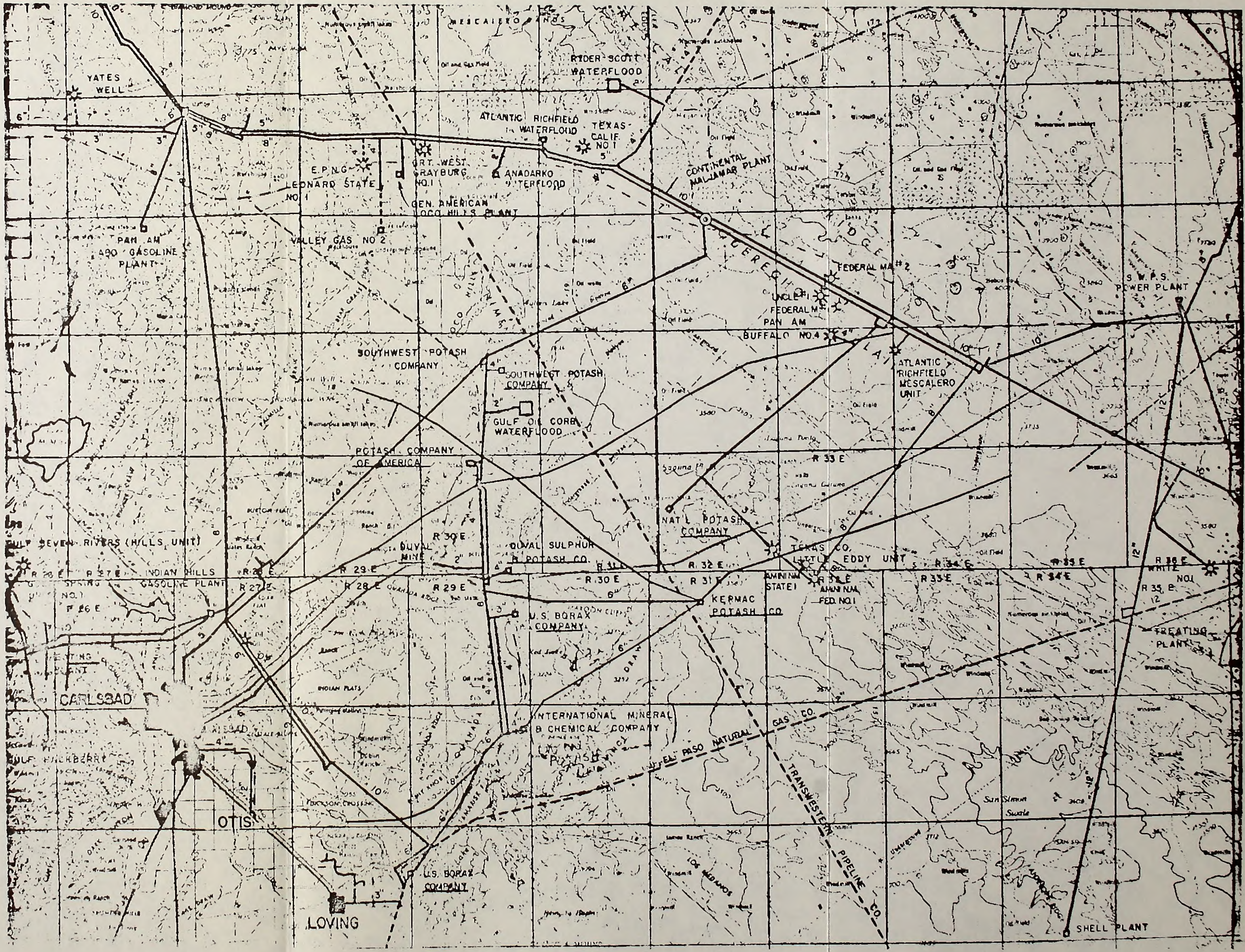
Table II-85 gives a summary of potash refinery production and operating data and gives an indication of the resources used by the various refineries.

Table II-86 gives a summary of potash production, employment, payroll, taxes and local expenditures. These items will give the reader an understanding of the relative economic significance of the individual refineries and the total industry.

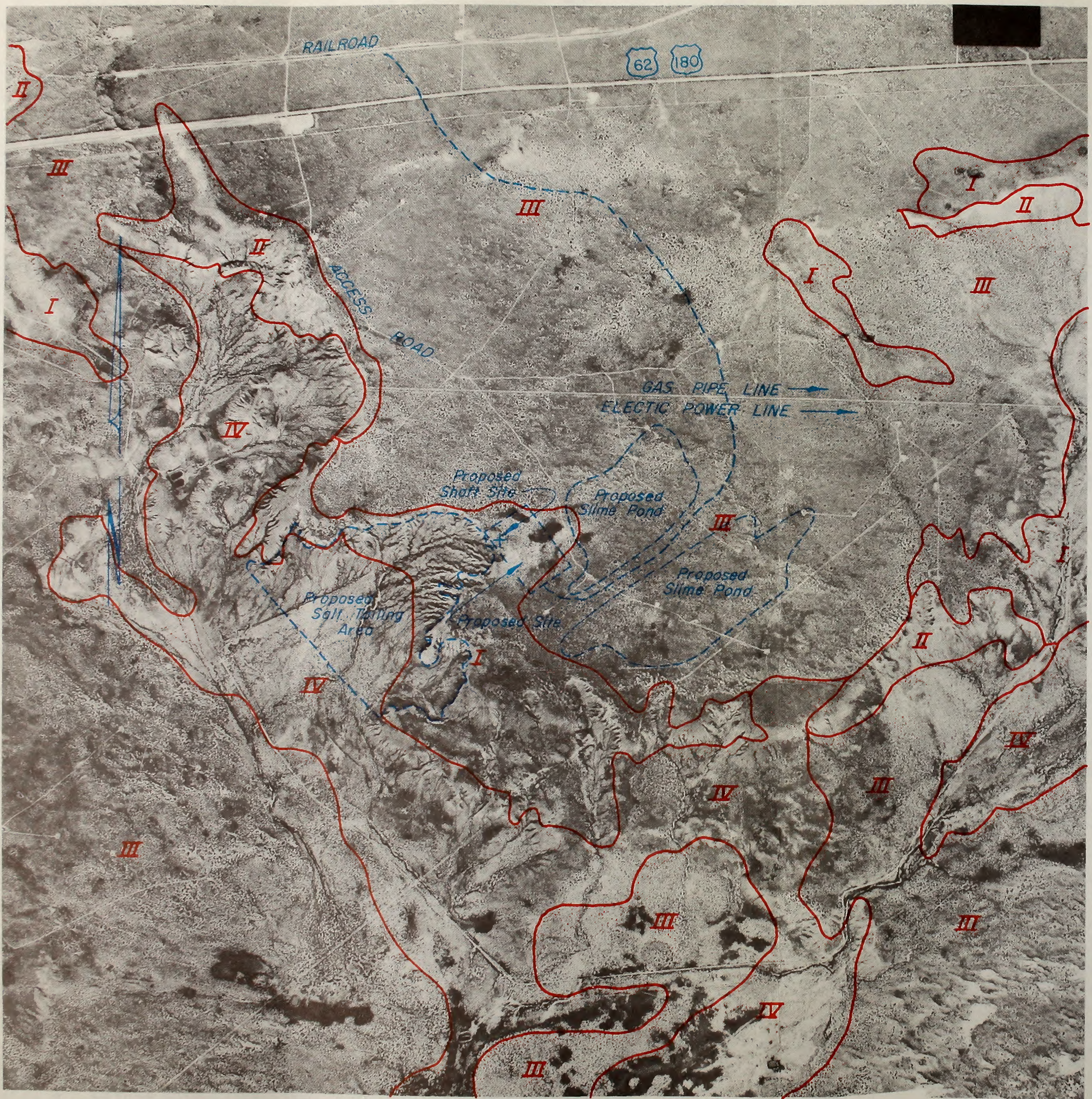
The present cumulative support facilities necessary to provide these resources along with access faciliites are summarized as follows:

Natural gas pipelines	70 miles
Water pipelines	160 miles
Electric transmission lines	110 miles
2-Lane access roads	20 miles
Railroad	50 miles

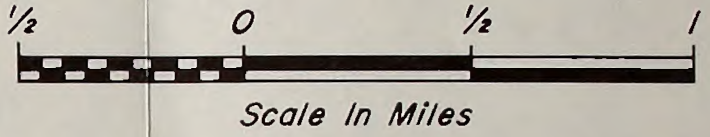
Map II-7, p. 169, Map II-23 in back pocket and Map II-24 show the gas pipelines, water pipelines and electric transmission lines supporting the potash industry. The railroads and most of the access roads are shown on Map I-1 in back pocket.



MAP II-24 GASLINE MAP FOR POTASH REFINERIES



MISSIPPI CHEMICAL CORP.
(PROPOSAL SITE)



Scale In Miles

LEGEND

IV SOIL TYPE

Map II-25

G. Mississippi Chemical Corporation - Proposed Mine and Refinery Site

1. Environmental Description - Conditions Typical in Study Area

Several environmental elements of Mississippi Chemical Corporation's (MCC) proposed mine and refinery site are similar to those typical of the Study Area and will not be discussed in detail here. These elements are Air (p. II-1), Hydrology (p. II-168), Geology (p. II-136), Land Use Suitability and Compatibility (p. II-295), and Ecological Interrelationship (p. II-211). Please refer back to the pages noted for the information.

2. Environmental Description (See Map II-25)

a. b. Topography - Drainage

Mississippi Chemical Corporation's (MCC) proposed mine and refining site is on the dune-like topography of the uplands, approximately three miles east of the present company operations. The location is close to steep escarpments, and breaks to lower elevations of terrain. Local relief at the top of the cliff site is approximately 100-150 feet difference in elevation from the landscape below. The breaks are dominated by rough, broken, and shallow soils. The major drainage at this site flows into Nash Draw.

c. Soils

The soils at Mississippi's proposed mine and refinery site represent most of the soil groups found in the overall Study Area. (The following references were consulted in elaboration of soils: Standard Soil Survey, Eddy Area, 1971; Lea County, 1974).

Berino soils are deep, sandy soils that have developed in wind worked material of mixed origin and represent an extensive area near the proposed site. These Group III occur on gently sloping, undulating to hummocky areas, with rounded dunes of fine sand being characteristic of the soils. They are subject to continuing wind and water erosion, and where vegetation is depleted, the erosion hazard may become severe. Nearly all the moisture that falls on the soil is retained, but because of the low water holding capacity of the surface layer, the soils lack surface water except for short periods after infrequent heavy rains. Permeability is rapid in the surface layer and moderately slow in the subsoil. These soils are susceptible to piping, and have moderate seepage if used as ponds and embankments. Sandiness of the surface material necessitates mixing with the subsoil if dikes are to be constructed with these soils. If excessive salts accumulate in these soils, normal precipitation will leach most of the salts out of the active root zone, although some build up does occur in the less permeable subsoil at depths below 30 inches.

The Rockland, Tonuco (Group I) and the Stony Rough Broken land (Group II) soil series are located on the narrow breaks and escarpments near the site. These areas are not extensive and occur between the sandy soils of the uplands and the alluvial fans of the landscape below. They range from noncalcareous soils that have been worked by wind to thin soiled ridge tops of indurated to weakly cemented caliche. Highly dissected, fractured reddish colored sandstone and siltstone also occur on these positions. These soils are thin with either indurated caliche or gypsiferous materials encountered at shallow depth. Excessive salts are difficult to leach from these profiles because of the shallowness to an impermeable layer. Soil is thin, and revegetation is difficult because of the steepness of the soils. Current surface erosion in the natural drainage to the northeast of the proposed refinery has exposed a gypsiferous layer near the surface which may indicate areas of a thin mantle of soil in these positions on the landscape.

The Largo soil series of Group IV consists of deep, loamy, calcareous soils that have developed on gentle slopes in alluvium, derived from upland sedimentary materials. They occur as alluvial fans below the breaks and escarpments, and are slightly eroded by water. V-shaped gullies are common in the drainage ways. Permeability is moderate, and the water holding capacity is high. If vegetative cover is depleted, good management is required to keep the soil from eroding. This soil is good for core material of embankments, but is unstable if used as surface topping of structures. If used on dike construction, a level grade is required, as this soil is unstable and susceptible to water erosion.

d. Vegetation

The vegetation surrounding this area is typical of shallow soils on the western side of the site, and deep sands on the east side of the site. The shallow soils are occupied by creosote bush and very little other vegetation on the areas, which shed water very rapidly, with exceedingly little infiltration. The drainage bottoms, are in general, washed to bedrock and contain mostly brush species such as catclaw, javalina bush and broom snakeweed.

East of the proposed site are shallow sands overlying caliche. On these areas, there is a dense stand of mesquite brush with mesa dropseed, plains bristle grass, bush muhly and remnants of black grama. The area is coppiced dunes, with broom snakeweed occupying the dune interspaces.

There are two areas north of the site where water gathers before infiltrating or evaportating. These areas support dense stands of mesquite brush and also have a stand of perennial grass. North of these areas are deep sands, which are basically occupied by shinnery oak and dropseed grasses.

South of the site, shallow loamy soil occurs, with the vegetation as described in soils, Group I. (See Appendix A-8)

e. Wildlife

The general wildlife habitat situation in the vicinity of the proposed MCC mine and refinery site is similar to the study area; however, one aspect is somewhat unique in the site. The uniqueness is associated with the topography of the site which includes the maroon cliffs area and the breaks area sloping into Nash Draw. The Maroon Cliffs provide perching and nesting sites for raptors which utilize the entire region and the breaks area provides protective cover for deer.

f. Aesthetics and Recreation

The proposed Mississippi Chemical refinery site is atop narrow cliffs, near the head of Nash Draw. This area has a commanding view of Nash Draw as far south as Salt Lake, and of the majority of Hat Mesa, which lies to the southeast. The site itself is visible from portions of U. S. 62/180 and New Mexico 31, south of the existing IMC refinery.

The overall aesthetic quality of the proposed location is relatively high, in comparison to that of the Study Area as a whole. In addition to the oportunities for predator, small game hunting and off-road vehicle use of the proposed site and surrounding lands, there is also open space value in this area.

g. Archaeology

This proposed site is in the middle of the proposed National Register District, and cultural site density is in the vicinity of 15.2 sites per square mile. There are approximately 45 sites in the direct area of proposed facility construction, and many other sites are adjacent to this area. These sites are not only dense, but cover large areas.

h. History

The potash discovery well is approximately 3/4 mile north of Mississippi's proposed new refinery site. This well was drilled in 1925, and as a discovery well, it qualifies for nomination to the National Register of Historic Places. Two large wooden bow wells, which were utilized in the drilling operation, now remain at the site and they are protected by fencing and an overhead shelter.

III. Analysis of Proposed Action and Alternatives

A. Environmental Impacts

1. Anticipated Impacts of Proposed Action

It is assumed that the proposed action will result in doubling the Carlsbad potash production in 20 years with addition of up to 7 new mining and refining operations. The environmental impacts of expanded potash production are reviewed and analyzed in this section. These environmental impacts will occur if no mitigating measures are applied during implementation of the proposed action.

To a great extent the impacts described in this section are generally similar in nature to some of the conditions resulting from the operation of the existing refineries. The conditions generated by the existing refineries are described in Part II, "Existing Environment." Therefore, the reader is cautioned against reading Part III, "Analysis of Proposed Action and Alternatives", without first having read Part II.

This analysis of impacts will consider regional impacts associated with all anticipated potash operations as well as the more specific proposal of Mississippi Chemical Corporation to build a new mine site and refinery. Other company proposals are either too indefinite to analyze or fall within the concepts of overall industry expansion as set forth in the Regional Analysis. In accordance with requirements of NEPA and 43 CFR Part 23, site specific analysis of environmental impacts of the actions will be completed as a part of considering any action for approval.

The general assumptions used to analyze the environmental impacts are shown in Tables III-1 and III-2. The assumptions used to analyze the social economic impacts are covered immediately following the social economic impacts in Table III-3 page

TABLE III-1

ESTIMATED FUTURE DEVELOPMENT OF THE POTASH INDUSTRY USED TO ANALYZE IMPACTS

	Minimum	Maximum
New Mines	0*	6
New Refineries	1	7
Miles of New Road	3	25

TABLE III-1

ESTIMATED FUTURE DEVELOPMENT OF THE POTASH INDUSTRY USED* TO ANALYZE IMPACTS

	Minimum	Maximum
Miles of New Gaslines	1	25
Miles of New Waterlines	2	275
Miles of New Railroads	3	30
Miles of New Powerlines	1	20

*The Mississippi Chemical Corporation proposal is for a new shaft to improve operations of an existing mine.

TABLE III-2

ESTIMATED ACREAGE REQUIREMENTS USED TO ANALYZE IMPACTS

Facility	Acres Required
Exploration Program	
Drill pads for 20 years	150 to 200
Access roads for 20 years	150 to 200
Mine Site (each)	10
Refinery Site (each)	80
Brine Ponds) per refinery Tails pile)	500
Support facilities per refinery	150

a. Proposed Action

(1) Air

The proposed action will have no impacts on air quality and noise levels within the individual existing refineries. Based on the assumption that any new refineries will have air and noise qualities resulting from provision of the latest inplant technology for control of air and noise sources, the overall in-plant air quality for the entire industry will be improved, and the noise levels will be reduced. This regional impact will be long term.

The proposed action will have an adverse impact on ambient air quality in Region 5. All phases of construction would have short-term site specific low adverse impacts on ambient air quality. This impact would result from wind erosion of soils which are depleted of vegetative cover and which therefore, contributes suspended particulate material to the air. Regionally this impact will be low and short term.

Refinery operations will have a higher adverse impact on the region because the proposed action assumes that 7 new refineries will be constructed. These refineries will increase particulate emissions in Region 5. State and Federal ambient air quality standards for particulates are currently being exceeded within the Potash Study Area. New facilities will have to meet new source emission standards administered by New Mexico Environmental Improvement Agency. The permissable emissions will be defined following diffusion modeling to assure compliance with relevant suspended particulate standards. The actual ground level concentrations of suspended particulates observed at any location in the Study Area would be a function of the geographic distribution of any new refineries. Regionally, the intensity of this impact is indeterminant because precise geographic distribution date for the proposed action is not available. It is not possible to calculate potash area ground level concentration of suspended particulates for the proposed action until specific information is available on the stack heights and locations, effluent gas velocities and temperatures, and particulate emissions for each of the new refineries.

The existing refineries do not currently produce emissions of NO_x, CO, hydrocarbons and SO_2 in quantities which cause New Mexico and Federal ambient air quality standards for these pollutants to be exceeded. Although the amounts of these pollutants may increase slightly, new refineries would be required to provide control equipment to assure compliance with the applicable air quality standards for these gases. It is not possible to make calculations for ground level concentrations of these gases until specific information, as cited above for particulate ground level concentration modeling is available.

The proposal to remove the Ozark evaporators at International Minerals Corporation will cause a site specific and regional improvement in air quality of the potash area. This beneficial impact is quantified on several computer maps. These maps and accompaning narrative is included in residual impacts (p. III-__) because they relate closely to residual air emissions after emission control equipment is applied to the other refinery equipment.

(2) Water

(a) Water Use

The environmental impact associated with water use by the potash industry is limited to refinery operations. The potash refineries now use 8,500 acre feet of fresh groundwater annually from the Ogallala aquifer (Caprock) and 3,500 acre feet of fresh water annually from the Capitan Reef aquifer. It is estimated that new potash refineries will use technology similar to existing refineries; therefore, it is estimated that water use by new refineries will range between 150 and 600 acre feet of water per 100,000 tons of product.

Water for new potash refineries will probably come from the Caprock aquifer since the water supply in the Capitan Reef aquifer is totally appropriated. Water in the Caprock aquifer is presently being used faster than it is being replenished; therefore, it is being depleted and potash operations are contributing to the depletion. This depletion is a long term regional impact; however, the depletion due to potash operations is not large compared to the depletion due to other uses; also water not used by the potash industry would eventually be used by other industries, agriculture, or municipalities.

(b) Hydrology

The surface activities associated with potash exploration will have no significant impact on hydrology because there are no flowing streams in the Study Area. The drilling activities will have no impact because the holes are cased through the interval containing aquifers. Upon completion of drilling, the holes are cemented and sealed from the bottom to the surface.

Mine development and mining will have a slight adverse impact on hydrology due to penetration of some aquifers by shafts. This penetration will allow the vertical movement of water or brine among aquifers.

Problems may be encountered in sealing the mine shaft to prevent groundwater or brine leakage. These problems are usually solved by grouting and temporary or permanent pumping of the leaking aquifer. If the aquifer yields water of good quality, the water can be used for refinery operations. (To be discussed later). If, as is usually the case, the leaking aquifer contains very poor quality water or brine, the water or brine may still be used for restricted refinery operations where it is eventually contained in tailings ponds. At places the water or brine may be impounded in earthen reservoirs where some may leak and pollute aquifers containing better quality of water above the leaking aquifer. At other places the water or brine may seep laterally to flood existing playas. These impacts are judged to be site specific and potentially long term because it may be more feasible to pump a small quantity of seepage permanently than to totally seal a shaft. These impacts were judged to be low because of the dominantly poor quality of the groundwater in the Study Area. On a regional basis these impacts are judged to be negligible.

The construction and operation of support facilities for the potash industry is judged to have no impact on hydrology because of the lack of surface streams.

The potash industry uses 12,000 acre feet of fresh water annually and discharges approximately 10,000 acre feet as brine effluent. The effluent from the refineries is discharged into tailings ponds which may leak. Once in the ground, the effluent flows vertically to pollute the groundwater or brine aquifers or laterally into existing playas converting them to more or less perennial lakes. Increasing the number of refineries will increase the number of tailings ponds and brine lakes and will probably increase pollution of underground aquifers. In view of the uncertainties of groundwater hydrology in this area, it is possible that any increase in brine effluent may increase the potential of brine leakage into the Pecos River. These impacts are judged to be long term because of the anticipated long life of the potash industry. These impacts are judged to be mostly site specific.

In addition to the brine effluent the potash refineries also discharge more than 3 parts sodium chloride for each part of sylvite which is produced. It is estimated that about 200 million tons of sodium chloride tailings are piled adjacent to refineries. The processing of lower grades of potash ore will increase the ratio of salt tailings to sylvite; therefore, it is anticipated that the salt tailings piles will continue to increase at rates equal to or greater than the present 14 million tons per year. These salt piles cause an adverse impact on hydrology since the salt piles are exposed to rainwater which promptly becomes saturated brine in the course of running off the salt piles. This brine from rainwater runoff is normally retained behind dikes where it may seep into the ground polluting local aquifers or it may add brine to nearby playas. The magnitude of this impact is dependent on the amount and intensity of rainfall, size and location of the tailing pile, and the amount of leakage. This is judged to be a long term site specific impact because it is anticipated that the salt tailings piles will remain on the surface well beyond the operational life of the potash industry. The regional impact is negligible because of the limited number of existing and proposed tailings piles.

At the present time there is no indication that the potash refineries are directly or indirectly causing brine to flow into the Pecos River. See page II-179 . An analysis of the geology and hydrology of the Study Area indicates that at some undetermined time in the future the effluent brines from the potash industry could possibly seep into the Pecos River. The probability of such seepage, the probable location of the seepage, the time when it will commence and the volume and flow rates of such seepage can not be estimated without long term intensive studies.

The environmental impacts on hydrology from potash refining operations described herein have not been classified as either beneifical or adverse. The impact of adding brine to groundwater is debatable because most aquifers contain only very poor quality (Brackish) water or brine. Wherever brine contaminates usable groundwater the impact should be classified as adverse. However, the magnitude of the impact probably ranges from low to negligible.

The conversion of playas to perennial lakes, even though they contain brine, is probably beneficial because it creates a habitat for wildlife, i.e., fairy shrimp, fish, ducks, geese and shore birds. The addition of perennial water to the arid landscape of the Study Area is probably a moderately beneficial impact on the aesthetics. The potential for polluting the Pecos River with brine effluent is a possibility but present data do not permit an evaluation of this hazard.

Potash lease abandonment will impact water use beneficially since the water used for refinery operations will stop. This is judged to be a long term beneficial impact since the water supply, assuming one remains, will then become available for other more beneficial uses.

The impact on hydrology from lease abandonment may be beneficial or adverse, and is generally limited to small areas within the region. Playas which are maintained as lakes by effluent seepage will probably begin to transform back to dry playas causing a corresponding change in wildlife habitat and aesthetics. The hazard of polluting groundwater supplies and the Pecos River will be reduced since the seepage will cease. Intermittent seepage of brine may occur from the runoff of rainwater from tailings piles.

(3) Land

The proposed action will result in impacts of varying degrees on soils. These impacts will occur as a result of mechanical disturbances from construction as well as from foreign particulates, effluent and other waste material from potash operations.

In all phases, establishment of caliche and other aggregate pits for construction materials will have highly adverse impacts site specifically on the soils. These impacts will be the result of the complete removal of productive soils from the pit sites and increased erosion potential due to removal of vegetative cover. The impacts will be short term in duration because the pits will revegetate soon after construction. Regionally this impact has little significance because of the relatively small size and anticipated small number of these sites.

Site specifically, exploration activities will create low to moderate adverse impacts of short duration. Impacts will vary with the degree of exploration activity and/or the different soils encountered. The removal of surface soil and its protective vegetation for pad preparation and access roads will result in the unprotected area being exposed to excessive wind and water forces. Wind action will blow the unprotected soil, reducing air quality and adding to soil loss.

The construction of drill pads and access roads will disturb, mix and alter the topsoil, thus destroying the existing microorganism community and soil-plant relationships. The soil structure will be altered appreciably from that which exists today.

Alteration of existing drainage patterns, resulting from pad preparation and access road construction, will have a minor adverse impact on downstream and adjoining areas because of deprivation of available soil moisture, thereby affecting the normal growth of protective vegetation.

Heavy drilling equipment will impact soils that are susceptible to compaction. Compaction alters soil permeability and reduces infiltration rates, thus increasing surface runoff, erosion and sedimentation. Regionally, these impacts will be of low intensity, since the amount of area affected is very small in comparison to that of the total Study Area. Exploration drilling is not dense; anticipated exploration of 600-800 holes over 20 years time will impact 300 to 400 acres.

Site specifically, mine development and mining will cause moderate to severe adverse impacts; those associated with waste pile sites will be of long duration, while all others will be short-term. Waste material and ore extracted from the shaft and initial mine panels will either be piled in the close proximity of the shaft or hauled away to the refinery site. Irrespective of the waste pile location, a severe adverse impact will be inflicted because the area of soil covered by the waste pile will be rendered sterile and nonproductive. Small areas around the waste site will be affected by an alteration of normal drainage patterns, as well as an accumulation of high salt levels in the soil from water run-off from the waste pile. This impact is considered moderate to severe, depending on the amount of water which will flow off the pile and leaching capabilities of the soil. The removal of surface soil and its protective vegetation will result in the unprotected area being exposed to excessive wind and water forces. Wind action will blow the unprotected soil reducing air quality and adding to soil loss. Construction activity will disturb, mix and alter the topsoil thus destroying the existing microorganism community soil-plant relationships. The soil structure will be altered appreciably from that which exists today.

If the waste material is transported to the refinery, a small adverse impact will result, as existing drainage patterns would be altered because of construction of the access road from the mine site. This will impact small downstream and adjoining areas. Permeability and infiltration rates will be altered by compaction thus increasing runoff, erosion and sedimentation. Regionally, all the impacts from mine development and mining will be negligible because of the small area involved in relation to that of the total Study Area.

On a site specific basis there will be moderate to severe adverse impacts resulting from refinery construction and operation. Constuction of refinery facilities and ensuing operations will disturb and remove from production an estimated 580 acres of soil surface area at each site. The management of tailings piles and brine ponds, as well as existing topography, will influence the acreage of the site. Operation at the refinery will introduce foreign particulates and effluents onto the soils in the proximity of the site. Severe adverse impacts will also occur on the soil beneath the brine ponds and salt tailings. These products of the refinery operations render the soil sterile and nonproductive because of excessive salt. Excessive salts in the soil will deplete or eliminate protective vegetative cover, thus exposing the soils to erosional forces of wind and water. Increased erosion, sedimentation, loss of soil and pollution of the atmosphere by particulates will subsequently occur. Air emissions from potash refineries will cause excessive accumulations of salt in the soil, on a site specific basis. A decreasing accumulation of excessive salt in the soil generally will occur out to a distance of one-quarter mile from the refinery. Within this perimeter vegetation mortality, species change and defoliation, leads to increased erosion because the soil is not protected by vegetation. The deposition of salt, etc. on the soil alters such characteristics as permeability, infiltration rates, structure, etc.

Even though the area of refinery oeprations will be larger than the mine site, the regional impacts remain low because the site will be relatively small compared to the extensive one million acre area being studied. If the industry continues to develop and doubles in size, approximately 8,000 acres would be affected by refinery sites.

Impacts on soil incurred on the refinery site, beneath the brine ponds and tailings piles are extremely permenent and would continue long past the life of a refinery. The impacts of decreasing value, occurring from the refinery site out to a distance of one-quarter mile or more, caused by air emissions are of long-term duration, because they will last for the life of the refinery before salt begins to leach out.

In addition to the soil losses and surface disturbances associated with mining and refinery activities, construction of support facilities will introduce additional impacts on soils. In constructing roads and railroads to the refinery, topsoil along the entire route will be disturbed, mixed and altered, thus destroying its present microorganism community and soil-plant relationships. The construction activity will appreciably alter soil structure from that which exists today. The loss of protective vegetation will induce increased erosional conditions and subsequent soil loss. The equipment necessary for this construction, may cross soil areas that are susceptible to compaction, and would thereby impact soil permeability and water infiltration rates. This will result in increased surface runoff, erosion and sedimentation. An estimated 2.5 acres of soil productivity will be lost for each mile of supporting railroad which is constructed because of rights-of-way for the tract balast slopes, etc.

Approximately 4.0 acres/mile of 2 lane access road will be lost as long as the road is in use. Support roads and powerline construction will disturb an additional estimated 2.5 acres of soil per mile by destroying topsoil characteristics and increasing erosion, with resulting loss of soil particles to wind action. Gas and waterlines construction will disturb and alter the soil along the entire route, because much of the soil surface must be excavated in preparation for pipeline trenches. Depending on location, impacts will be inflicted on soil structure, permeability, infiltration rates, etc. This adds to compaction, increase in erosion and loss of protective vegetative cover. Surface soils will be exposed to prevailing winds and intense rain storms. Gas and waterlines will each disturb approximately 2.4 acres of soil area per mile of pipeline. The waterlines may encompass more total area because they are extending greater distances to the water source.

If the industry doubles in its development, an estimated 900 acres will be affected by the construction of all support facilities associated with it. Although these areas will include more acreage than exploration pads, etc., they are small in comparison to the total study area, and will inflict low intensity regional impacts.

Impacts inflicted by support facilities such as railroads and roads may be long term in nature, as soils will be lost to productivity as long as the facilities are used. Impacts from gas lines, waterlines and power lines will be short term in duration, because once construction is complete, some degree of recovery will occur.

All activities which occur prior to lease abandonment will impact the soils. Surface disturbances which alter soil structure, permeability, infiltration rates, compaction properties and vegetative cover will be stopped during lease abandonment. Even when deposition of salt is stopped, a low adverse impact from the accumulation will continue until soil readjustment occurs. When the soils have readjusted, a low to moderate beneficial impact will be initiated because of reestablishment of an adapted vegetative community. This results from the curtailment of refinery particulate and effluent that adversely affect soil and vegetation. The areas impacted under brine ponds, salt tailings and specific refinery sites will have long term sterility because of high salt level concentrations.

(4) Minerals Resources

The most important impact on the mineral resources by the active and proposed mining and processing is the impact on potassium-bearing ores. Large tonnages of ore will be mined from the Carlsbad mining district and exported from the area, mostly for use as plant nutrients. An estimated 592 million short tons will be mined during the 1975-1995 time interval, with the resultant depletion of the nonrenewable potash resource. This quantity of ore comprises about 16 percent of the total economic resource, which is estimated to be present in the mining district. It also comprises as much as 45 percent of the remaining higher grade ore reserves (an average grade of 16 percent K_2O) estimated to exist as of 1974. In addition, in the refining process an undetermined amount of potash will be entrained in brines. These impacts are judged to be long-term regionally because of the depletion of the mining district.

Oil and gas recovery in the mining district will be temporarily delayed in places, because well locations interfere with mining operations or potash reserves and thus drilling will not be permitted; however, most recoverable hydrocarbons will be produced from offset locations or from directionally drilled holes, either during or subsequent to mining activity. This adverse impact is judged to be low and of long-term duration because the life of some potash mines will be as much as 50 years. It is considered to be regional because of the widespread occurrence of potash in the mining district.

Aggregates will be used in construction in the mining district and in adjacent areas. Total aggregates consumed will be a negligible quantity of caliche, limestone and other rock available for use as aggregate from within the Study Area. Site specifically, this adverse impact is judged to be low and of long-term duration; regionally, it is considered to be negligible because only minor amounts of aggregate will be used for the potash industry.

The common salt (NaCl) associated with the potash which will be mined and stacked or entrained in brines in large quantities will comprise only very small amounts of the tremendous tonnages of salt within the Study Area. This impact is regional in nature, of long-term duration and is slightly beneficial. A small percentage of this salt is used for road salting and for livestock. If demand for this waste salt increases, this impact will become significantly more beneficial.

A beneficial impact on the recovery of oil and gas from the Study Area may possibly occur as a result of potash lease abandonment. Abandonment would make the surface of leases available for well locations to allow for vertical recovery of oil and gas reserves. This is only a possibility as no data is available on the feasibility of drilling through a second mined area.

(5) Vegetation

Exploration activities would have moderate to high adverse impacts site specifically on vegetation. Surface disturbance for construction and road building would destroy vegetation on site, and surrounding vegetation would be impacted through alterations in soil characteristics such as drainge, microorganisms, compaction, etc. These impacts are judged to be short-term because the disturbed areas would vegetate in a relatively short time unless the road to the drill pad is required for further service. Regionally, this impact would be low to negligible, because only 300-400 acres would be affected in the Study Area.

During mining and mine development there would be a high adverse impact on vegetation site specifically. In addition to destruction and alteration of vegetation resulting from surface construction, vegetation would also be impacted by the large amounts of waste material which is usually piled next to the mine shafts. The area under the waste pile would be denuded of vegetation, and if the waste contains a high percentage of salt, the covered area would become sterilized. Polluted rainwater flowing from these waste piles would impact vegetation around the perimeter of the piles.

Regionally, the impact would be negligible, since the estimated cumulative area for mine development would be small (approx. 70 acres) in comparison to the size of the Study Area. These impacts are judged to be long term because they will continue for the projected 25 to 50 year life of a mine.

Site specifically, the impacts on vegetation from refinery construction and operation would be highly adverse and of long-term duration. As in other phases, surface disturbance for refinery construction would destroy and alter vegetation. Surrounding individual refineries, there is also an adverse impact on vegetation resulting from refinery air emissions which contain salts. This salt accumulates in the soil and alters soil characteristics to the extent that vegetation is destroyed, damaged, or altered in species composition.

The areas of most severe impact on vegetation would be the salt tailings piles and brine pond sites. At these locations the vegetation would be totally and permanently destroyed. The cumulative acreage estimated to be involved in these refinery sites, tailing piles and brine ponds would reach about 8000 acres with full anticipated expansion of the potash industry.

The areas immediately surrounding the tailings pile and brine ponds would also be impacted. Polluted rainwater flowing from waste piles, tailings piles and brine ponds cause soil sterility and change species composition in the perimeters of these sterile sites. The additional brine waters which are expected to collect in the area would transform playas into perennial lakes and thereby reduce the vegetative community around these lakes.

Regionally, the impacts from refinery construction and operation would be slightly adverse and of long-term duration because the area involved is small in comparison to the total size of the study area. These impacts are judged to be long term because the impact of the air emissions will continue for the 25 to 50 year life of the refinery, and the tailing pile and brine pond sites may never be able to be revegetated.

Site specifically, the impacts resulting from construction and operation of support facilities such as roads, railroads, powerlines, etc. would be moderately adverse and of short-term duration. Vegetation would be destroyed during construction of powerlines, gas lines, waterlines, but would come back on these areas within a relatively short period of time. On roads and railroads, vegetative production would be eliminated for the period of use. Regionally, the impacts would be low to negligible, since the area involved for these support facilities is small in comparison to the size of the total Study Area. It is estimated that approximately 150 acres would be involved for these support facilities for each refinery site.

Site specifically, lease abandonment would have a beneficial impact on vegetation because the cessation of air emissions and surface disturbance would permit soil and vegetative readjustment. However, the area covered by tailings piles and brine ponds would continue to impact vegetation adversely. In addition, spreading salt piles would increase this impact. Some of the salt would be carried down the side to the tailings piles onto the soil and some would flow directly into the brine pond. The impact of the salt would be highly adverse site specifically and of long term duration since it would kill the vegetation and sterilize the soil preventing revegetation. The beneficial impact of eliminating existing air emissions and surface disturbance is also long term. Regionally, these impacts would be considered negligible in view of the area involved in comparison with that of the entire Study Area.

(6) Wildlife

The impacts on aquatic animals during exploration will be slight both site specifically and regionally due to the limited amount of water in the Study Area. Impacts on terrestrial species during exploration will be severely adverse on small mammals, reptiles and invertebrates on a site specific basis due to noise disturbance and habitat destruction by road and drill pad construction. The impact on other species will be slight due to their mobility. Regionally the impacts of exploration on all terrestrial annimals will be slight because of the small size of the area which will be disturbed during exploration (an estimated 300 to 400 acres) compared to the total size of the Study Area. Exploration impacts will be short term, unless the road to the drill pad remains in use after exploration has been completed.

The impacts on aquatic animals during mining and mine development will be slight both site specifically and regionally due to the limited amount of water in the Study Area. The impacts on terrestrial animals during mining and mine development will be severely adverse on small mammals, reptiles, and invertebrates on a site specific basis due to the noise disturbance and habitat destruction. There will be a slight impact on other terrestrial species due to the mobility of these larger animals and birds. Additional habitat may be altered or destroyed by polluted rainwater flowing from tailings piles. The regional impact of mining and mine development on all terrestrial species will be slight due to the small area of habitat destruction (an estimated 70 acres) compared with the total acreage of the Study Area. The impacts of habitat destruction from mining and mine development will be long term because they will generally persist throughout the operation of the mine (20 to 50 years).

The construction of refinery support facilities (i.e. power lines, gas lines, waterlines, railroads, etc.) will have the same impacts on wildlife as the exploration activities described above. However, the operation of electrical power lines adds the possibility for a high adverse site specific impact on raptors due to bird electrocutions. Regionally this is a low adverse impact associated with potash due to the many transmission lines in the Study Area which are not directly associated with potash operations. The New Mexico Game and Fish Department does not have any evidence of current bird electrocution problems in the Study Area.

The construction of potash refineries will have the same environmental impacts as those described earlier under mining and mine development. The only difference will be in the magnitude of the impact as defined by the area involved. A mine development area will encompass about 10 acres, while a refinery site including brine ponds and tailings piles will encompass about 580 acres. This will involve destruction of habitat and displacement of the small mammals, rodents and reptiles living in the area.

The operation of potash refineries has a highly beneficial site specific impact on aquatic species. Aquatic species make only sparing use of the refinery brine ponds. However, some of these ponds have underground seepage which percolates into nearby playas and maintains these playas as year around lakes. The refinery effluent is apparently diluted during the time it is underground; therefore, the lakes, although very high in dissolved salt content, provide desirable habitat for fairy shrimp, migrating ducks and geese, resident shore birds, and the only fish species found in the Study Area. The regional impact of the refinery operation is considered moderately beneficial for aquatic wildlife because of the relatively limited acreage of playas which could possibly be converted into perennial lakes by seepage. This is considered to be a long term impact because the refineries will operate for 20 to 50 years.

The impact on terrestrial animals from refinery operations will be a high adverse impact on small mammals, reptiles and invertebrates on a site specific basis due to habitat loss caused by covering the land surface with salt and brine which kills vegetation. An area up to one-quarter mile in radius around the refinery will experience a low adverse impact on wildlife due to certain vegetation species changes, defoliation, and vegetation mortality caused by air emissions from the refineries. It should be pointed out that a species change involving the conversion to four-wing saltbush will have a moderately beneficial site specific impact on big game species due to the improved browse which is generated. The overall regional impact on wildlife will be only slightly adverse because of the small area impacted and the comparatively large size of the Study Area. The impact is considered to be long term because it will last for the life of the refinery operation which is estimated to be 20 to 50 years.

The impacts on aquatic animals during lease abandonment will be adverse to the extent that the lakes maintained by seepage revert to playas and cease to support certain aquatic species. Regionally, this is a moderately adverse long term impact caused by shutting down the potash refineries and/or sealing the seepage from certain effluent ponds.

The impacts on terrestrial animals during lease abandonment will be moderately beneficial on a site specific basis due to the land which will eventually be revegetated and returned to the status of wildlife habitat, and the cessation of flora-toxic air emissions. Regionally, this will amount to a slightly beneficial long term impact due to the small amount of land involved. The land under the salt tailings piles and the brine ponds will probably never be revegetated.

If in the future potash refinery brines enter the Pecos River, the impact of such brine upon aquatic wildlife depends upon the salt tolerance of the animals and the amount of dilution which occurs in the river. This dilution depends upon the volume of river flow as well as the volume of brine entering the river. In addition, the present flow in the Pecos River downstream from the potash Study Area contains very high concentrations of salts during certain periods of the year. Species which are now surviving have tremendous tolerance for salinity; therefore, species which will be surviving at the time potash brines influence the river should have a tremendous but unknown tolerance for salinity. Accordingly, the importance of this impact is unknown.

(7) Ecological Interrelationships

Exploration activities would have a low to moderate adverse impact on ecological interrelationships site specifically. The construction of roads and drill pads would clear vegetation and wildlife from the immediate site. The denuded soil surrounding roads and pads would be exposed to wind and water erosion, and compaction which would lead to altered drainage patterns and disruption of the microorganisms necessary for soil productivity. The decrease in soil productivity would cause an adverse impact on vegetation and on the herbivorus wildlife which depend on this vegetation for habitat and food. The impact on herbivores would directly impact carnivores through depletion of food supply. In addition, carnivorous birds would be impacted by a decrease in nesting habitat through the destruction of large trees. On a regional basis this impact would be low to negligible, and of short-term duration.

Mining and mine development would also have a moderate adverse impact on ecological interrelationships site specifically. In addition to impacts described above resulting from construction, ecological interrelationships would be further impacted by waste piles near the shaft. If this waste contains salt in quantities detrimental to soil productivity and vegetation, the area surrounding the pile may become sterile as a result of polluted rainwater flowing from the pile. Even if the salt does not completely destroy vegetation, salt would accumulate in the soil and would alter soil productivity so that natural vegetation is damaged or inhibited in growth. There may be a vegetative change to species which are salt tolerant. All of these alterations in soil-vegetation relationships would result in altered wildlife interrelationships. Populations of insectovores, herbivores and carnivores would fluctuate with available habitat and food supply. On a regional basis these impacts would be low since the area involved is quite small when compared to the size of the Study Area. Mining and mine development impacts are long-term.

The adverse impact on ecological interrelationships resulting from refinery construction and operation are more severe site specifically than those of other phases of the potash industry. Refinery operations impact ecological interrelationships in all the ways described in exploration and mining above except the area involved is much greater. In addition, refinery air emissions cause accumulations of salt in the soil which in turn causes visible alterations in vegetation out to one-quarter mile around the refinery. Salt accumulations would cause alterations along the entire chain of ecological interrelationship: drainage, soil productivity, microorganisms, vegetation, herbivores, insectovores, carnivores. In the most affected area all ecological processes would be destroyed. At places within the perimeter of the affected area, there may be changes in vegetative species composition and a corresponding change in wildlife.

The areas of most severe impact on the ecological interrelationships during refinery operations would be the salt tailings piles and brine ponds, where ecological processes are totally and permanently disrupted. The total acreage so affected at present is some 4,000 acres and could reach over 8,000 acres with full anticipated expansion of the industry. On a regional basis this impact would still be low, because the Study Area is so large. These impacts would be of long-term duration.

Construction of support facilities would have a low to moderate adverse impact on ecological interrelationships site specifically. Construction activities would disrupt and destroy ecological processes as described above. Construction of pipelines and powerlines would have a short-term impact because soil would readjust quickly after construction is completed. Railroads and roads, however, would have a long-term impact because soils could not readjust as long as these facilities are in use. Regionally, the impact on ecological interrelationships from construction of support facilities would be low because of the limited area involved.

There would be a low to moderate beneficial impact on ecological interrelationships site specifically at lease abandonment. The cessation of refinery air emissions and surface disturbance would allow the natural ecological processes to become reestablished. The tailings piles and brine pond would still be unreclaimed. These beneficial impacts would be low on a regional basis because of the small area involved.

(8) Aesthetics & Recreation

The exploration phase of potash operations within the Study Area has varying potential for both adverse and beneficial impacts on aesthetics and recreation resources. On a site specific basis, the construction of roads and drill pads for exploration would add an estimated one quarter mile of additional unnatural scars, per drilling site, to the landscape. These scars would be long-term in nature, and in relation to the existing environment would have a moderately adverse impact. In terms of recreation resources on a site specific basis, the impacts of exploration would be totally contingent upon the specific locations of the test sites.

It is possible that exploration could have a slightly beneficial impact on recreation from the standpoint of improving hunter access and providing "jeep" trails for off-road vehicle users within the Study Area. These also would be long-term impacts. The other operations involved in the exploration process, such as the actual drilling of the test holes, would have negligible impacts.

The regional impacts of exploration activities would be the cumulative effects of a number of individual test sites located throughout the region. Given the existing condition of the aesthetic and recreational resources within the region, these cumulative effects would add an estimated 75 to 100 miles of roads and trails to the area which could also be considered scars. These would have only a slight adverse impact, although they would be long-term in nature. The factors generating these impacts would be roads, drill pads, and monument pipes.

Mine development and mining phases of new operations in the potash basin would have negligible impacts on recreation, both site specifically and regionally. In relation to the visual resources, the impacts would be slight and could be either adverse or beneficial, depending on the cultural background and bias point of view of the observer. The predominant factor associated with mine development, which would impact the visual character of the Study Area, is the location and construction of the headframe. There are currently two types of headframes in use within the Study Area. The first is the "traditional" steel lattice work type of headframe. (Photo III-1). The second is the modern reinforced concrete "Koepe" hoist. (See Photo II-17, page II-350). To some observers, any type of man-made structure that appears on the broad expanse of the plains is an undesirable intrusion. To others, the appearance of the "traditional" headframe adds a point of interest to an otherwise monotonous vista and fits with the impression of a western mining area. The modernistic appearance of the "Koepe" may add a point of interest, but does not fit well into the typical western mining theme. It is currently anticipated that 1 to 15 additional headframes would be added under the proposed action. Regardless of the type of headframe used, this would be a long-term impact because the headframe would be in use until abandonment of the lease.

It is anticipated that under the proposed action, 1 to 7 new refineries will eventually be constructed. This would

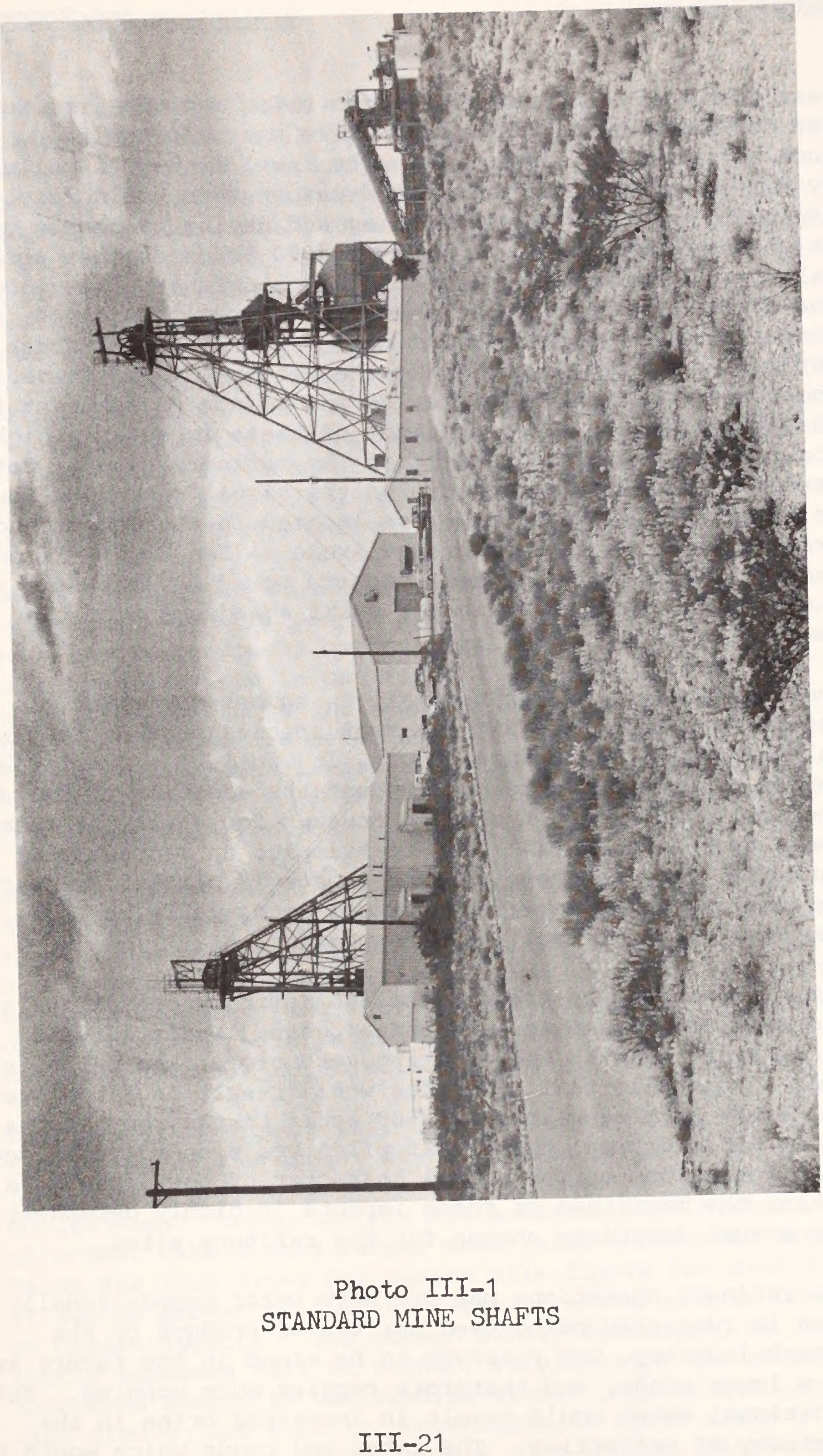


Photo III-1
STANDARD MINE SHAFTS

result in an additional 4000 acres being removed from public use for hunting and off-road vehicle use. In addition, as much as a two fold increase in the level of visual pollution by air emissions from dryers and evaporators would result, depending on the type of refining and drying processes used in the new refineries. A loss of 4000 acres of open space values could also result, dependent on refinery site location. The aesthetic effect of refinery structures themselves is similar to that of headframes discussed above. Although the refineries do not actually fit the western mining theme, some observers feel that they do add points of interest to the visual scene. The magnitude of these impacts is highly contingent upon the placement of the refinery sites. Both positive and negative impacts on the visual resources would be higher if the refineries are located in the foreground areas instead of the background areas. (See Map II-11 on Page II-231). All of these impacts would be long-term as the structures would be in use until abandonment of the lease.

The salt content of refinery air emissions may cause a vegetative change to salt tolerant species such as four wing saltbush. If this change occurs, it would be a beneficial impact on deer and antelope through the addition of browse species. The addition of food sources for these game mammals would have a beneficial long-term impact on recreational hunting. The magnitude of this impact is slight, however, because there are very few deer and antelope in the area. Regionally this impact would be negligible.

The two dominant by-products of the refinery operations are the salt tailings piles and brine ponds. Under current conditions and with the existing technology, the establishment of the salt tailings piles would result in a long-term or nearly permanent loss of 3500 acres to the recreational user. In addition, these salt piles would constitute long-term intrusions on the visual character of the Study Area. Again, the magnitude of these impacts is highly dependent on the actual locations chosen for the refinery sites.

New refinery operations may use more water proportionally than is currently being used per ton of product by the potash industry. Ore reserves to be mined in the future are of a lower grade, and therefore require more washing. This additional water would result in increased brine in the vicinity of refineries. The lakes and ponds which would be created or expanded would have a slight beneficial impact in that they add an element of variety to the landscape.

The support facilities necessary for a potash refinery, consist of roads, railroads, power lines, waterlines, natural gas pipelines, septic tanks and garbage dumps. The construction of 1 to 7 new refineries anticipated under the proposed action, would necessitate approximately 3 to 25 miles of new roads, 3 to 30 miles of railroad spur lines, 1 to 20 miles of power lines, 3 to 300 miles of pipelines, 1 to 7 septic tanks and sanitary landfills. These would not have a significant impact on recreation from the standpoint of removing excessive acreage of land from public use. These actions would in fact improve access in some portions of the Study Area for the recreational user. From the standpoint of open space and aesthetics, however, these facilities have the potential for adding up to 375 miles of visual scars to the landscape in the form of unnatural linear features.

Lease abandonment would have only beneficial impacts on all aspects of aesthetic, open space and recreation values. For each lease abandoned, approximately 600 acres of land would be reopened to public use for all forms of recreational activities suited to the Study Area. In addition, open space and visual character would be enhanced by the removal of the refinery facilities from the leased lands.

(9) Cultural Resources

All impacts on cultural resources are permanent and irreversible. Site specifically, exploration activities will have a significant adverse impact. Cultural resources located on or adjacent to an exploration activity will be destroyed or severely damaged. Those cultural resources in the vicinity of the activity will become better known to the public and more accessible and subject to damage.

Regionally the impact will still be adverse but less significant, since the amount of total area affected by exploration activities is very low in comparison to the total potash area. Approximately 400 acres will be directly affected, with a much larger area being indirectly impacted. Using the 15.2 sites per square mile figure for site density, it can be projected that at least 12 sites will be destroyed by direct impacts. The number partly destroyed, or indirectly impacted will be higher, varying with the amount of increased access to surrounding areas. Exploration activities also do not tend to concentrate in those areas of higher site density expectations (i.e. dunes, playas or cliffs), but are disturbed more or less uniformly throughout the region.

Site specifically mining and mine development would have a significant adverse impact on cultural resources since any cultural values located at the mine site will be destroyed. In addition, cultural values in the vicinity will be made accessible to pothunters.

Regionally, the impacts will be adverse with the degree depending upon the location of the various mines. This reduction in adverse impact is due to the small percent of the total region impacted by mine development. Approximately 70 acres will be directly impacted, while the indirect impact may extend several miles in each direction from the mine location. The increased access to surrounding areas provided by the road and shaft area encourages pothunters to search around the mine area and to damage sites. Approximately 3-4 sites will be directly destroyed and approximately 30-60 indirectly impacted through exposure to pothunters.

Site specifically there is a significant adverse impact, since all cultural values in the area of the refinery will be either destroyed or damaged. The impact is especially high, since the favored locations for refineries at present, appear to be the same as those chosen by the prehistoric inhabitants of the area (i.e. playas, high points and dune areas). This will probably not change in the future, since sites are chosen at present with specific needs of the refineries in mind (i.e. low lying areas for brine containment). A greater number of cultural values appear in these particular environments than, for example, in the bottom of a draw.

Regionally the impact is significantly adverse, since the refineries take up a larger area than do mines or exploration activities. In addition, the propensity for locating refineries in favored prehistoric site locations is a contributing factor. A third factor involves the number of refineries located in the potash area. If we consider that each refinery utilizes approximately 580 acres for refinery salt tailings and brine ponds, and if we consider an average of 15.2 archaeological sites per square mile, then approximately 14 sites are destroyed per refinery location. These are the sites directly impacted. Indirectly approximately 4 square miles around each refinery is affected by increased access. Approximately 60 additional sites are involved here and will be either destroyed or damaged.

Regionally, there is a possibility of 1 to 7 new refineries operating within the potash area, or 72 to 504 sites destroyed in the process of new refinery construction and operation.

Site specifically the impact is significantly adverse, since cultural values in the right-of-way will be destroyed or severely damaged.

Regionally, the impact will be less adverse, but still significant, since many of the support facilities (i.e. railroads, powerlines, gaslines) utilized by the potash industry are long and cross many differing environmental zones. The chances of directly or indirectly, impacting cultural values in this situation are great. Crosscutting environmental zones increases the chances of encountering sites, especially if some of the zones crossed are favorable site locations (i.e. dunes, playas). Approximately 150 acres of surface facilities will be directly impacted by each refinery, or approximately 3 sites per refinery if the 15.2 per square mile figure is used. However, the Mississippi pipeline survey encountered 21 sites within 182 acres, or a density of about 60 sites per square mile. This is probably due to the crosscutting of a number of environmental zones. Support facilities of a linear nature should then be considered to have a more significant impact on the cultural values than nonlinear facilities. The indirect impact is also great, since all areas along the right-of-way are opened to increased traffic and pothunting.

Site specifically and regionally, there will be few or no adverse effects on cultural resources from lease abandonment, since the facilities will have already impacted cultural values. There might be a slight beneficial effect due to less visitor traffic in the areas surrounding the facilities and transportation network deterioration, but this is questionable. Abandonment may encourage traffic which was previously discouraged by refinery personnel.

(10) Sociol-Economic Conditions

The analysis developed in this section is based upon the assumption that a minimum of 1 new potash operation may be built in the near future (by 1980), with a maximum of 7 new potash operations in the future (1990-2000).

The socio-economic impacts (environmental impacts) are quantified, to the extent possible with existing data. In the case of socio-economic impacts, the specific location of the facility has no bearing on the impacts to be expected. The regional impact for one new operation will be the same as the site specific for 1980, but will be a cumulative range for the period 1990-2000. The probability is recognized, that based on current leaseholds and investments, the pattern of resource development and growth will continue. Exploration will be conducted within the present economic framework without an increase in employment.

Expansion of the potash industry (increased development of the potash resources) of Eddy and Lea Counties, with associated increases in employment and population, will have varying impacts on the socio-economic conditions of the Study Area. This is the foundation and causes of many of the secondary impacts associated with the increased expansion of the Potash Industry.

Population

Population projections for the counties in the Study Area, from the present to the years 1990-2000, are only estimates of the conditions considered likely to occur, based on the assumed minimum and maximum increased potash operations, not predictions.

Based on the Bureau of Business Research population projections in the Study Area (Eddy and Lea Counties), population will increase from 90,673 in 1970 to approximately 244,500 in the year 2000. During this 30 year period, based upon the average employment of the present 7 potash operations, population will increase by 1287 in 1980 and increase 9009 by the 1990-2000 period. Eddy County will experience the greatest percentage increase of the two counties in the Study Area.

Based on the average employment for the present potash operations, population will increase from 90,673 in 1970 to 91,960 in 1980, and increase to 99,682 by the 1990-2000 year period (based solely on the assumed increase in potash operations).

The two major population centers of Carlsbad and Hobbs will experience the vast majority of the population increase.

Employment

Employment projections for the potash industry, based on the assumption of a minimum of one new potash operation by 1980, to seven new operations by 1990-2000, are as follows:

Table III-3

EMPLOYMENT PROJECTIONS FOR THE POTASH INDUSTRY

	1970	1980	1990-2000
Study Area	2749	3139	5498
Eddy Co.	2474	2825	4948
Lea Co.	275	314	550

Certain economic sectors will be impacted as a direct result of potash lease development and employment. Agriculture may be impacted the most by the loss of employment to potash related industries. Agriculture cannot be expected to offer salaries comparable to those of the potash industry.

With the advent of increased railroad transportation needs due to potash operations, it is anticipated that railroad employment will increase as expansion of the potash industry takes place.

Impacts from expansion of the potash industry will initially occur on employment with construction of the first additional operation and will develop along with the assumed maximum development of 7 new operations. It is anticipated that local operating enterprises will sufficiently handle the construction demands and that impacts will be site specific and have a minimum impact on the Study Area unless all new operations are constructed in a short time period. The skilled labor required appears to be available in the area, in the amounts required for peak construction periods.

Impact on other residentiaries is a direct function of population and employment in the basic sectors. Although a precise numerical relationship does not exist between employment in the basic sector, plus construction and employment in other residentiaries, an estimate can be made. The ratio of basic plus construction employment to total employment in the Study Area for 1970 was .37 (See Appendix C-8.) Thus, one additional employee in the potash sector induces a total employment of 2.7 persons, the difference being attributable to other residentiaries. This indicates that for each employee in potash, more than two employees are induced in other residentaries.

In summary, development of potash industry (based on study area assumptions) will provide a number of basic and secondary jobs; for each new operation, 390 (industry average) jobs will be provided in the potash sector plus 1014 additional jobs. By 1980 this will mean 1404 new jobs; this will increase to 7098 (cumulative) for the 1990-2000 year period.

Income

Average income for the potash industry employee, in 1974, was about $11,100 per annum. Whether or not this income is sufficiently attractive to lure employees to the Study Area, is unknown. While income of the potash workers will be substantial, incomes of supportive workers may be relatively lower. The average income of the induced labor force will be greater than that of the Study Area ($9,210). As income for supportive employment is likely to approximate the mean family income of the Study Area, and given the anticipated relatively high income of the potash workers, personal income in the Study Area will increase.

Housing

The housing demand for the Study Area will be 33,448 units in 1980 and 39,142 units for 1990-2000, relative to the 1970 base of 32,044. Approximately 1,404 more units will be required in the Study Area by 1980 than existed in 1970 to meet the rising population and resultant demand. The 1990-2000 housing demand is 7,098 units more than 1970 totals and 5,694 units more than existed in 1980. The greatest increase in housing demand will occur in Carlsbad. No account was made for vacancy rates which would occur in the housing market; therefore, housing demand may be underestimated.

Education

Expansion of potash resources in the Study Area will cause an increase in area population between the present and 1990-2000. With a rise in population levels and immigration of various work forces with associated families, public schools will realize substantial increases, particularly in Carlsbad. Increasing student enrollment, in turn would impact enrollment capacities of existing school district facilities.

Student enrollment will increase by about 350 students in the Study Area by 1980, and increase about 1,775 by the 1990-2000 period.

By 1980, the influx of a work force (including temporary and permanent works) and associated families would place a moderate demand on school enrollments of the Carlsbad School District. At the present capacities of existing school facilities and the number of full-time teachers, the district would be able to adequately cope with enrollment in 1980. By the period 1990-2000 enrollment would exceed capacity in elementary schools by 796. In junior high and senior high schools, capacity would be exceeded by 230, assuming the potash will double by that time (capacity data furnished by Superintendent, Carlsbad Municipal Schools).

Based on the average pupil-teacher ratio of 23 to 1 (See Appendix C-28), the district schools would require 11 additional teachers in 1980. The number of additional teachers needed by 1990-2000 would be 86.

Health and Social Services

Expansion of potash operations in the Study Area and their attendant population increase will impact several elements of the health and social service systems. Elements already in scarce supply will be impacted the most.

Health

Existing manpower, facilities, and services will be impacted by the increase in population.

Manpower

The Study Area is already short of personnel in virtually all health manpower categories. The Study Area has few physicians, dentists, and optometrists to serve the existing local population. Projected population increases will intensify an already serious situation.

The health manpower (Table II-73, page II-276) presents the number of personnel engaged in each of 7 health fields for the Study Area's major population centers. Based upon the current ratio of manpower to population (.9/1000, Eddy County), a set of manpower requirements was estimated for the periods 1980 and 1990-2000. Relying on population increases generated solely by potash employment expansion, manpower requirements were calculated as a function of population. The manpower requirements will increase by two for 1980 and by nine for the 1990-2000 period. The health manpower requirements are probably underestimated due to the low present ratio.

Facilities

The Study Area currently has an ample supply of health facilities. With the exception of long-term nursing beds, the 6 hospitals and 2 nursing care facilities have sufficient capacity to meet present needs.

In projecting future needs, uncertainties as to future utilization rates limits the reliability of estimates generated.

The Study Area populations who will be served by health facilities in the future will not necessarily reflect present utilization patterns.

Using the ratios of 3.9 and 4.1 per 1,000 population for acute beds and long-term beds, respectively, approximately 359 acute beds will be needed by 1990-2000. About 386 long-term beds will be needed in 1980 and the need will increase to 419 long-term beds by 1990-2000. With a present stock of 396 acute beds and only 53 long-term beds, the impact of increased bed requirements will not be significant for acute beds for the 1980 or 1990-2000 periods. However, the impact on long-term bed requirements will be very significant. At the present there is a deficit of 327 long-term beds, this deficit will increase to 333 in 1980 and increase to 366 in 1990-2000.

Services

As with manpower and facilities, health services impact will be a direct function of the added demands generated by population growth and the ability of the community to accommodate the growth. Perhaps more than any other health service sector, mental health and alcohol treatment will be most sensitive to pressures of rapid development. The effect of such development on the health service sector is extremely difficult to predict. It is anticipated that development in the Study Area will not be rapid (boom-type) growth; therefore, the impact on health services will be minimal.

Social Services

Impacts on social services are dependent upon such variables as size and composition of the incoming population, the ability of various social service sectors (sanitation, law enforcement, etc.) to accommodate this population, and the psycho-social characteristics which enable these newcomers to adjust to a new and unfamiliar environment.

It should be noted that although the public assistance function will not be seriously affected by expansion of potash development, certain isolated impacts may occur. Although the incoming population will generally be well paid and self-supporting, many residents already on public assistance will remain dependent on such support. The expansion of potash development is anticipated to be gradual, thus affecting the cost of living only slightly. A minimal impact is expected on those persons who are on fixed, and generally low incomes.

Law Enforcement

Expansion of potash operations with its attendant rise in population will impact the law enforcement personnel and facilities within the region. With a rise in population and immigration of various types of people, crime levels will change to undeterminable new levels. Based on population increases above, and present ratios of enforcement personnel per 1,000 population, an estimate can be made of the number of enforcement personnel which would probably be required to provide the present rate of law enforcement. These estimates can be compared to the existing situation, thereby providing some measure of the magnitude of impact.

Sheriff Departments

Table II-78 on page II-81 presents the full time manpower for sheriff departments in the study area. Based upon population increases due to potash expansion, and using existing ratios, requirements for sheriff department's manpower will be 32 in 1980 and increase to 35 by 1990-2000. The present manpower is 31.

Municipal Police Departments

Table II-79 on page II-281 indicates the full-time municipal police department manpower for the four major cities in the Study Area. At present, the municipal police manpower is 137. The population increase will require the manpower to be 139 by 1980 and increase to 153 by 1990-2000.

Fire Protection

The present make up of fire protection manpower is 63 percent full-time and 37 percent volunteer firemen. The total manpower in the Study Area is 120. Estimated need or manpower requirements will be 123 by 1980 and increase to 134 by 1990-2000.

Utilities

City officials and utility respresentatives indicate that future consumer demands for utility use and installation can be easily made without undue delay. Impacts on utilities will be minimal in 1980 and 1990-2000.

Water and sewer

Based on average consumption and average sewer use, the present systems capacities can accommodate future expansions in potash development in 1980 and during 1990-2000.

Community Attitudes and Lifestyles

Present attitudes in the Study Area are overwhelmingly pro-potash development and are not likely to change; therefore, impacts will be minimal. Impacts on life styles will also be minimal and affect only those persons on fixed incomes. (See impacts on social services).

Summary of Social-Economic Impacts

Proposed Action	
Population	
Population increase	1,287 by 1980
" "	9009 by 1990-2000
Employment	
Employment increase	1,404 by 1980
" "	7,098 by 1990-2000
Income	
Total personal income increase	$13,667,950 by 1980
" " " "	$70,532,280 by 1990-2000
Housing	
Housing demand increase	1,404 units by 1980
" " "	7,098 units by 1990-2000
Education	
Student enrollment increase	350 by 1980
" " "	1,775 by 1990-2000
School facilities capacity	below capacity by 1980
" " "	exceeded 1,026 by 1990-2000
Teacher requirement increase	11 by 1980
" " "	86 by 1990-2000
Health and Social Services	
Health	
Manpower	
Manpower increase	2 by 1980
" "	9 by 1990-2000
Facilities	
Acute bed increase	5 by 1980
" " "	35 by 1990-2000
Long-term bed increase	6 by 1980
" " " "	33 by 1990-2000
(Present deficit)	(327)
Social Services	
Services	
No impacts	by 1980
Minimal impacts	by 1990-2000
Law enforcement	
County sheriff staff increase	1 by 1980

County sheriff staff increase	4 by 1990-2000
Fire protection	
Manpower increase	3 by 1980
" "	14 by 1990-2000
Utilities	
Minimal impact	by 1980
" "	by 1990-2000
Water and Sewer	
Minimal impact	by 1980
" "	by 1990-2000
Community Attitudes and Lifestyles	
Minimal impacts	by 1980
" "	by 1990-2000

Analysis Assumptions

1. Valuable potash resources will be made available for utilization.

2. Water utilization and consumption will increase for industrial uses, possibly reducing amount available for other uses.

3. Energy resource utilization (electric and natural gas) will increase for potash development, possibly reducing amount available for other uses.

4. The employment, public school, and housing populations will increase due to potash expansion because no offsetting decrease in these populations is anticipated from other segments of the existing populations.

5. Tax and royalty income will be increased within the study area.

6. Income levels will increase within the study area.

7. All infrastructural facilities will be impacted.

Analysis Guidelines

1. Cumulative impacts will be analyzed for a minimum of one new potash operation and a maximum of 7 new operations.

2. New potash operations will be similar to present operation in size and method of operation.

3. Population base is 1970. Increase in study area is for Eddy and Lea Counties. Social economic impacts are analyzed based on the two counties, with emphasis on the two major population centers (Carlsbad and Hobbs).

4. Each family unit will consist of 3.3 persons. There will be 250 families per 1000 population.

5. Each family unit will have 1.0 school age child or 250 school age children per 1000 population.

	No. School age children/family
Elementary School	.50
Junior High School	.25
High School	.25

6. Housing requirements (acreage) calculated on the basis of six single family units per acre and 3.3. persons per family unit.

(11) Land Use Suitability and Compatibility

Implementation of the proposed action or alternatives may have an adverse impact on land use by the oil and gas industry within the Study Area. If the prospecting permits included in the proposed action lead to expansion of the secretary's potash area, the oil and gas industry may be forced to drill through salt horses or to utilize off-site directional drilling techniques. Due to the large oil and gas reserves known to exist within the region outside of the Study Area, this would be a moderately adverse impact. To date, no attempts have been made to drill vertically through areas which have been second mined for potash. For this reason, a determination cannot be made as to whether this would be a long-term or short-term impact.

Should potash exploration indicate significant mineable deposits of potash ores within the thirty-three square mile ERDA atomic waste test site, it would no doubt have to be included as a factor in any decision making process concerning implementation of an atomic waste storage program in the area.

If the potash industry within the Study Area expands to the maximum indicated in the proposed action, approximately 8,000 acres (4000 existing plus 4000 due to expansion) would be removed from forage production. This means the grazing capacity of the Study Area would be reduced by 100 cows yearlong. This would not be considered a highly significant adverse impact but it would be long-term in duration. A possible beneficial impact to the livestock industry would also occur. This would be in the form of additional water available to livestock operators from potash company pipelines. However, due to the generally poor quality of the area for livestock grazing, this would be only a slightly beneficial impact.

The increased demand for water which would be generated by the expansion of the potash industry could alter the land use patterns within the Study Area. Existing water rights currently being used for agricultural irrigation may be purchased by the potash industry and converted to mining and industrial use.

In the realm of industrial conflicts, it is possible that expansion of the potash industry may introduce competition between the potash industry and other industries within the area for the available labor force. Expansion of the industry will also increase the demand for electric power and gas. This in turn may force implementation of state established priorities for allocation of these resources in the event of shortages.

Maximum expansion of the potash industry would make approximately 8,000 acres (4000 existing plus 4000 due to expansion) within the Study Area unsuitable for wildlife and recreational use. This would not be a significantly adverse impact based on the overall site of the study area. A potentially adverse impact would also result from the alteration of the visual character of the area to one of expanding industrialization. This impact, although adverse, is probably not highly significant due to the generally low visual quality of the Study Area.

Expansion of the potash industry with its attendant surface disturbances would eliminate certain acreages from suitability for archaeological or other cultural resources studies.

In the process of making this analysis, consideration was given to the risk of spilling potash during transportation from the refinery to the point where the potash is further processed for use in the fertilizer and chemical industries. Almost all of the potash is transported from the Study Area by railroad; therefore, the analysis is limited to the railroad shipping which is done by Santa Fe Railway Company.

Santa Fe Railway Company was quiried concerning their past five years and they responded as follows:

"Our records show that during the past five years, out of more than 400,000 rail cars of potash hauled, 408 cars were derailed. Spills resulted from 158 of these derailed cars. Only one of these spill incidents resulted in potash going into a body of water. Over the five year period, less than 4/100 of one percent of the potash we transported was involved in spills."

"Cleanup operations following a spill begin immediately. Understandably, the length of cleanup time varies with the magnitude of the spill, but generally speaking, cleanup is completed within a three-day period."

"In past years, potash involved in a derailment or spill was considered unacceptable by the shipper to be further transported to the final destination. The railroad, responsible for disposal, utilized in most cases outside firms to transfer by means of grain augers, belt conveyors, or vacuum devices, the non-damaged potash into other cars to be sold to salvage companies. The remaining potash was plowed into the ground along our rights-of-ways. During the last year, however, due to the scarcity of the product, some potash, after being transferred into other rail cars, is shipped to the final destination."

"The derailment referred to in the second paragraph resulted in three carloads being spilled onto a private lake owned by Santa Fe. Each year during the dry summer months, the water evaporates from this lake. This summer, we will attempt to recover as much of this potash as possible and dispose of it in some manner acceptable to local regulatory agencies."

Letter dated May 12, 1975

"Of the 408 derailments which occurred during the past five years, 146 were on spur lines from the potash mines and refineries or in refinery yards."

Letter dated June 17, 1975

In light of the information presented above, it was judged that there are no siginificant environmental problems associated with potash transportation which could be meaningfully analized as a part of this study. Therefore, the subject of potash transportation will not be carried further in this analysis.

(12) Mississippi Chemical Corporation - Proposed Mine and Refinery

(a) Air

The impacts on ambient air due to the air emissions from the proposed MCC refinery can not be analyzed by computer because the necessary information is not available (i.e. stack height and diameter, emission velocity and termperature etc.). However, based on the existing air emission regulations for new point sources, MCC must submit data to EIA so that EIA can model the proposed emission and determine the level of emission control which MCC would be required to meet. The emission level would be designed to ensure that the State's ambient air standards are not exceeded by the new refinery. In view of the above, MCC's new refinery should have adequate air emission controls to avoid adding particulate matter to the atmosphere at a rate which would cause the ambient air standards to be exceeded.

(b) Land

The proposed MCC refinery will ultimately be larger than the estimated average refinery, because of the large ore reserves of the mine and the estimated tailings over the 50 year life of the operation. The planned MCC operation will ultimatley require about 1000 acres for tailings piles, brine ponds, and the refinery site.The construction of a new potash refinery by Mississippi Chemical will result in impacts of varying degrees on the soils within the area. These impacts, like those on other disturbed sites of the Study Area, will result initially from the mechanical disturbances of construction, and later as a result of the foreign particulate and effluent products from the potash operations. Adverse impacts will be introduced overall, both site specific and regionally, because an entirely new area is being disturbed and altered. The soil groupings which dominate the proposed site are I, III and IV. The deep sands are located on the gently sloping, undulating to hummocky landscape to the east. The shallow soils of the breaks, escarpments, and/or transition phase of the landscape are located in the proximity of the proposed refinery area and to the west. The deep, loamy soils are located on the alluvial fans at the base of the escarpments and breaks, further west.

Moderate to severe impacts will be introduced site specifically with the development of a mine site. Waste material and ore extracted from the shaft are generally piled in the close proximity of the shaft or hauled to the refinery. Regardless of waste pile location, a severe adverse impact is introduced because the soil covered by the pile will be rendered sterile and nonproductive. A small area around the pile is also affected by an alteration of the normal drainage patterns, as well as an accumulation of high salt content in the soils from the waters flowing off the pile. This condition around the pile will vary in severity, depending on the amount of water allowed to flow off the pile. The more sandy soils have the capabilities to leach the salts from the active root zone if given time. The soils with higher loam contents in the profile, as well as those shallow over caliche and/or gypsum will have an accumulation of salts, because of the presence of an impermeable layer with inadequate leaching properties.

The site specific incurred during refinery construction and operation will be of a moderate to severe adverse level on soils. The construction of refinery facilities and ensuing operations will ultimately disturb an appoximate 1000 acres of soil surface, much of which will be sterilized and permanently removed from production. The acreage of the affected area will depend upon where the brine ponds, tailings piles and waste areas are located and how they are designed and managed to minimize their size.

These shallow soils will be subjected to some refinery air emissions and it is probable that a detrimental salt accumulation will develop due to soil depth. The area and magnitude of the salt accumulation and its ultimate detrimental affect will be dependent upon the volume of salt carried and deposited by the air emission from the refinery. The salt accumulations may become great enough to kill off the protective vegetation in some areas, thereby, exposing the soil to excessive wind and water erosion. The areas under the brine ponds and tailings piles will become permanently sterilized and non-productive.

Even though the refinery facilities with all its support facilities would affect approximately 1,000 acres, it is small in comparison to the 1 million acres study site, and regionally the impacts would be low.

The impacts introduced on site, such as refinery, brine pond, tailings piles, waste piles, etc. are of long term duration while the others introduced are short term.

The construction of support facilities for the proposed MCC refinery will produce impacts like those described previously for the construction and operation of refinery support facilities. The MCC proposed refinery site will involve about 3 miles of railroad, 3 miles of access road, 1 mile of gas line, 1 mile of electric line, and 2 miles of water pipeline.

Abandonment of the proposed MCC refinery site will bring about an end to soil impacting activities, i.e. surface disturbance and particulate emissions. The result will be that the soils will begin to readjust. Salt accumulations will begin to be leached from the active root zone and soil microorgaisms will begin to reestablish. Only the areas under the tailings piles and brine ponds will be permanently sterilized due to the salt concentrations.

(c) Water

The construction and operation of the porposed new MCC mine shaft and refinery will have impacts on water usage because the refinery will require more fresh water than the existing refinery. The existing refinery has been operating on Rustler Formation water; however, it is presently being shifted to the Caprock water supply and detailed comparative water usage data is not available at this time.

The sinking of the proposed shaft may result in the penetration of aquifers and the fracturing of rock strata around the aquifers such that water or brine may flow vertically among the penetrated aquifers. This mixing of fluids within the aquifers will be adverse if the chemistry of the fluids in the aquifers is not similar because brine from one aquifer could be polluting fresh water in another aquifer. This is a site specific impact since a relatively small area would be involved.

The water used in the refinery and converted into brine effluent will be disposed of in ponds. At the proposed refinery site, the ponds would be situated on the Dewey Lake Redbeds which is one of the more impermeable formations in the Study Area. Accordingly, it is estimated that the brine ponds and tailings piles at the proposed refinery will not generate a significant amount of brine seepage due to the impermeability of the redbeds.

(d) Vegetation

The total development of the proposed MCC refinery site will result in the destruction and permanent loss of 1,000 acres of vegetation common to soil groups I, III and IV. This loss will be due to the land being used for tailing piles, brine ponds, and the refinery site.

Depending upon the magnitude of the air emission coming from the proposed refinery, there may be some adverse impacts on vegetation outside the 1,000 acres of refinery site, brine ponds and tailings piles. This impact would be due to salt accumulations developing in the soils and/or on the vegetation. At this time the type of impacts and the area which would be involved can not be determined. The area involved may be as great as one-quarter to one-half mile radius around the refinery. The actual impacts may range from negligible through a slight yellowing of some leaves, partial defoliation, total defoliation, mortality of some species, conversion to salt tolerant species and total sterilization of the soil due to excessive salt accumulations. The impact will be most severe on shallow soils near the refinery and less severe on the deep sandy soils farther from the refinery.

(e) Wildlife

The construction and operation of MCC's proposed potash refinery will have similar impacts on wildlife to those described earlier with two exceptions. First, the area of the proposed refinery and tailings disposal sites includes some of the better deer habitat in the Study Area. The operation of the refinery will ultimately destroy 1,000 acres of this habitat. The present deer population in the Study Area is small and the potential for developing a large deer population is limited; therefore, the significance of this impact must be considered in that light. Secondly, the area of the proposed refinery operations includes the Maroon Cliffs which are potential nesting and perching habitat for raptors. Refinery operations will disrupt or perhaps totally destroy the Cliffs' suitability for raptor habitat.

(f) Ecological Interrelationships

The ecological interrelationships will be impacted by the construction and operation of the proposed MCC refinery to the extent that 1,000 acres of soil productivity, vegetation, and wildlife habitat will be lost to tailings piles, brine pond and the refinery site. The small animal populations which live on this 1,000 acres will be destroyed or driven into adjacent areas which may or may not have the capacity to absorb the increased population. The only critical environmental element which may be lost is the potential raptor perching and nesting habitat associated with the Maroon Cliffs.

(g) Aesthetics and Recreation

The proposed Mississippi Chemical Corporation (MCC) site is located atop the Maroon cliffs approximately 2½ miles south of U. S. 62/180. The impacts of potash exploration on this site are already in evidence, as this phase of the operation has already been completed.

Mine development on this site would have significant adverse impacts on the open space and aesthetic values inherent to the site. This site has a moderately high potential for open space utilization and was rated as one of the areas with the highest scenic value in the entire study area. The location of the proposed Koepe hoist on this site would intrude on these values and significantly diminish their quality.

The construction and operation of a refinery on this site would further intrude on the open space and aesthetic values of the site to the point of negating them. The proposed method of disposing of the tailings solids is to dump them over the rim of the Marroon Cliffs. This method has the potential to significantly alter the character of these cliffs in both form and color. This would be a significant long term adverse impact on the visual character of these lands. One thousand acres of land and open space would be removed from public use.

The construction and operation of support facilities for the proposed refinery would have significant adverse impacts on the visual character and open space values of the site. Approximately 10 miles of linear scars would result from the construction of a paved access road, railroad spur, powerline and pipelines for water and natural gas.

The ultimate abandonment of this proposed site would return the land to public use. The visual intrusions of the Koepe hoist and the refinery facilities would be removed and the emission of visible pollutants would cease.

(h) Cultural Resources

The area northeast and southeast of the present refinery is an area of high cultural values which is part of a proposed National Register Region, and any surface disturbing activitiy in this area will have a very adverse impact on the cultural resource.

The proposed mine shaft development also falls within the proposed National Register Region, and as such would have a significant adverse impact on the cultural values in the area. Destruction of sites, as well as increased accessibility of significant sites to vandals, form a large part of the adverse impact, as does destruction of the integrity of the region if sites are disturbed.

Placing the new refinery in the east one half of section 9, and the slimes and brine in section 10 and section 16, would impact a large number of cultural values and for this reason, as well as those described above for mine development, the impact of refinery construction and operation is highly adverse.

A highly adverse negative impact is also expected from support facilities in terms of cultural values, for reasons described above. In addition, some of the support facilities (i.e. pipelines, powerlines) cover long distances and will have impacts on sites along the proposed rights-of-way.

There will be little or no impact on cultural resources by lease abandonment, since all damage will have already been accomplished.

(i) Socio-Economics

The socio-economics impacts of constructing and operating the proposed MCC refinery will be the same as the 1980 projected impact of building and operating a single refinery.

(b) Alternatives and Their Impacts Within Existing Authority

(1) No Action

The no action alternative would allow the continuation of existing potash operations, without benefit of the mitigating measures developed in this analysis, and would prohibit the development of new potash operations. The impacts of no action would be a perpetuation of the existing conditions described in the existing environment section (Part II) of this report. (i.e. continued air emissions, effluent discharges, vegetation and wildlife habitat losses, salting of soils, destruction of cultural resources, and visual pollution associated with air emissions, etc.)

Under this alternative the life of existing mines and refineries would be extended because existing leases could be mined from existing facilities, with perhaps less capital commitment than construction of new facilities. In this regard, further capital investment for the mining of potash could be greatly discouraged as the indecision of the United States becomes apparent. The final result of the no-action policy would be the eventual closing of mines and refineries as potash ores on present leases became exhausted and or facilities became no longer capable of competitive production. The closing of the mines and refineries will result in a loss of employment and increased social problems if some other form of employment is not available for the then unemployed potash labor force.

As increasing demand (shortfall) develops, the impacts of potash production would be transferred elsewhere; to other domestic producers to the extent of their ability to compete effectively, or to foreign producers and areas, to the extent of the National ability to pay for potash imports.

(2) Delayed Action (postpone action pending further study)

Impacts anticipated during the proposed delay would include only those continuing impacts which reflect the conditions of the existing environment. (See Part II).

If after the proposed delay, new lease stipulations cannot be developed from the additional data, and the proposed action is then approved, the anticipated impacts would be the same as those of the proposed action.

If this delay should result in the development of new lease stipulations, it is assumed that some of the adverse residual impacts would be less and some of the beneficial impacts would be greater than those of the proposed action. The degree to which these changes would occur can not be determined at this time.

(3) Alternate Site for Proposed Mississippi Chemical Corporation (MCC) Mine Shaft and Refinery

If MCC utilizes its existing refinery site the impacts on the following resources would be less than those described in the proposed action because less undisturbed land would be involved: soil, vegetation, wildlife, ecological interrelationships, aesthetics, recreation and cultural resources. Impacts on ambient air quality can not be determined because data is not available for comparison between the two refinery operations. The proposed new refinery site is considered to be a better site geologically for the development of sealed brine ponds. Therefore, it is anticipated that use of the existing refinery site will result in a greater amount of leakage from the refinery brine ponds than the proposal to construct the new ponds at the new site. Regardless of where MCC builds their proposed refinery, they will need a new water supply which will come from the caprock and cause the anticipated depletion of that aquifor. The difference in refinery site will not change the social economic impacts anticipated as a result of the construction and operation of a new refinery.

After the application of the mitigating measures, the residual impacts of this alternative will be the same as the residual impacts of refinery operations expected from the proposed action.

It is anticipated that the mitigating measures developed for the proposed action will be applicalbe to this alternative. Accordingly, the residual impacts should be the same as the proposed action with three notable exceptions. First, the unique wildlife habitat associated with the Maroon Cliffs would not be lost if the existing refinery site is utilized. Second, if the existing refinery site is utilized, the National Historic Register quality archaeological district at the proposed site will not be infringed upon by construction and operation of the proposed refinery. It should be pointed out that very little is known of the archaeological values in the vicinity of the existing refinery; therefore, the existing refinery site may also have high archaeological values. Third, and finally, the existing refinery site is in a less scenic area than the proposed site; therefore, the residual impacts on aesthetics should be considerably less if the existing refinery site is utilized.

(4) Alternate Water Source for Potash Refinery

The anticipated impacts of and mitigating measures for this alternative would be the same as those for the proposed action with few exceptions. There would be a beneficial impact on the water resource (primarily Ogallala aquifer) since less fresh water would be used for refining. There would be a lesser adverse impact on cultural values, soils, vegetation, and terrestrial and wildlife habitat because there would be less land disturbed for water pipeline construction, than is anticipated in the proposed action.

The implementation of this alternative may require treatment of the Rustler Formation water. This treatment could result in energy and chemical consumption and the generation of waste materials from the water treatment process. It should be kept in mind that the unknown impacts of water treatment could be more adverse than the benefits which might be derived in using Rustler Formation water.

The environmental benefits of this alternative can not be quantified until the following details can be determined:

Refinery Location
Primary Water Source Location
Local Water Source Location
Resource Values on the land involved in the two pipeline routes
Water treatment process which will be required
Chemical Consumption of the required treatment process
Energy Consumption of the required treatment process
Waste generated by the required treatment process

c Alternatives and Their Impacts Outside Existing Authority

(1) Delayed Action (postpone action pending further study)

Impacts anticipated during the proposed delay would include only those continuing impacts which reflect the condition of the existing environment. (See Part II.)

If after the proposed delay, new lease stipulations cannot be developed and the proposed action is then approved, the anticipated impacts would be the same as those of the proposed action.

If this delay should result in the development of new lease stipulations, it is assumed that some of the adverse residual impacts would be less and some of the beneficial impacts may be greater than those of the proposed action. The degree to which these changes would occur can not be determined at this time.

(2) Immediate Readjustment of All Existing Potash Leases

If the alternative of immediate readjustment of all existing potash leases were implemented, all the mitigating measures developed in this analysis would be applied to all existing leases at this time. There would be no delay until lease readjustment dates (in some cases up to 18 years in the future).

The environmental impacts of and the mitigating measures for this alternative will be the same as those described in the proposed action, except that 82 of the existing leases will be readjusted earlier under this alternative than under the proposed action. The result when compared to the proposed action, should be an undetermined decrease in the environmental degradation associated with the existing potash leases. The amount of such decrease can not be quantified until it is determined which mitigating measures can be implemented through the administrative procedures involved in 30 CFR Part 231, and which mitigating measures can only be implemented through the lease readjustment procedure.

(3) Export and/or Import Adjustments

This alternative has a great range of possible impacts on potash resources. Restrictions on exports could cause a drop in production at Carlsbad, because the present domestic market could not absorb that portion of the production which is presently being exported. The effect of increasing imports of potash would depend upon the price of the imported potash. High priced imported potash could make the Carlsbad deposits more competitive, and thereby cause a great expansion of Carlsbad potash production. The availability of large quantities of low priced, imported potash would break the potash market and the Carlsbad production would decline or even cease.

For the purpose of analyzing this alternative, it is assumed that there would be tight government control directed at the objective of using imported potash and limiting domestic potash production to domestic application. Under these conditions, it is assumed that the government would manage matters so that the Carlsbad potash companies would continue to operate, but expand at a much slower rate than is anticipated in the proposed action. The mitigating measures developed by this analysis would be used, and under the condition of slower expansion, it is anticipated that the environmental impacts would be less than that of the proposed action. Expansion would be over a longer time period, allowing for the development of improved pollution control technology. The impacts would last for a longer time period because the deposit would not be worked out as rapidly as anticipated in the proposed action. Also, improved technology may be developed, which would allow for the recovery of lower grade potash ores, and thus lengthen the life of the mining district.

The balance of payment problem is another factor relating to export and import adjustment. An adverse impact on the balance of payments will develop in proportion to the amount of export restriction and the amount of imports encouraged.

(4) National Potash Policy

The alternative of establishing a National Potash Policy is directed toward making more efficient use of potash and artifically decreasing the demand for potash. Accordingly, the proposed expansion of the Carlsbad potash industry will be slowed, and the economic life of the potash deposits will be prolonged. The mitigating measures for this alternative would be the same as those developed for the proposed action.

Under the condition of slower expansion, it is anticipated that the environmental impacts will be less than those of the proposed action. Expansion would be over a longer time period, allowing for the development of improved pollution control technology. The impacts will last for a longer time period because the deposit will not be worked out as fast. Also, improved technology may be developed, which would allow for the recovery of lower grade potash ores, and thus would lengthen the life of the mining district.

(5) Leaching and Crystallization Refining Process

The alternative of requiring the leaching and crystalization process will have the same environmental impacts those of the proposed action with two exceptions. First there will be an increased consumption of natural gas, and second there will be an increased level of carbon monoxide and oxides of nitrogen. The additional natural gas is necessary because the leaching and crystalization process requires more energy than the flotation process.

The additional carbon monoxide and oxides of nitrogen are generated by the combustion of the additional natural gas.

After application of the mitigating measures developed in this analysis, the residual impacts associated with this alternative would be the same as those for the proposed action with exceptions delineated above.

2. Mitigating Measures

The administrative procedures used in potash leasing offer several opportunities to protect the environment with the application of mitigating measures.

Mitigating Measures can be stipulations in prospecting permits, stipulations in leases, requirements of an exploration plan, requirements of a mining and reclamation plan, or stipulations inserted in an existing lease at the time of lease readjustment. In addition, mitigating measures to correct specific ongoing problems can be developed and applied at any time if the measures fall within the guidelines of environmental protection expressed in 30 CFR Part 231.

As shown on the flowchart of Potash leasing procedures, (Figure I-14 in back pocket), site specific environmental analyses and technical exams are required for each application, exploration plan, mining and reclamation plan, right-of-way and lease readjustment. Specific mitigating measures are best developed in the site specific EAR and technical exam because more specific details are available. It is the intention of the BLM to apply the mitigating measures which are developed in the site specific analysis, in addition to the appropriate measures developed in this analysis, at the appropriate step in the administrative procedure.

In the process of doing this regional Environmental Analysis Record, mitigating measures were developed to protect the environment. These mitigating measures are presented in 4 sections. The first section contains mitigating measures which are recommended for implementation by applying them as stipulations to permits, leases, lease readjustments, plans and rights-of-way. These mitigating measures will be applied to specific cases based on the analysis contained in the required site specific environmental analysis and site specific technical exam.

The second section contains mitigating measures which are highly recommended; however, they are not considered to be the type of action which would normally be required of a permittee or lessee. These mitigating measures will have general benefits and will require the cooperative efforts of the potash industry and several levels of government. It must be kept in mind that these mitigating measures can only be carried out if the necessary levels of cooperation, manpower, funding, and program emphasis can be obtained. To some extent many of these measures are being implemented at this time; however, they are presented here because it is believed that additional efforts along these lines would be very beneficial.

The third section of mitigating measures covers measures which may be possible, but they are not recommended due to the rationale set forth immediately following each measure.

The fourth section of mitigating measures covers items dealing with health and safety within the potash industry. These are considered desirable; however, they are outside the authority of the BLM and GS and fall within the specific responsibility of MESA.

Key: E Mitigates Exploration Activities
M Mitigates Mining Activities
R Mitigates Refining Activities
A Mitigates Lease Abandonment Activities

a. Mitigating measures for leases, permits, exploration, Mining and Reclamation Plans and Rights-of-Way (Recommended)

1. Install monitoring and air emission control equipment necessary to ensure that present and future New Mexico State Ambient Air Quality Standards are met when the refinery is constructed. (R)

   This mitigating measure is only applicable to new potash refining operations. The New Mexico State Environmental Improvement Agency (EIA) is the agency responsible for the monitoring and controlling of air emission sources. EIA issues a permit for all new air emission discharge points. In issuing a permit for a new emission point, EIA would model the emission pattern and require adequate emission control equipment to ensure that the ambient air standards are met.

   In the case of existing refineries, EIA can only regulate the emissions after the Environment Improvement Board (EIB) has established emission regulations for the potash industry. To date no regulations have been established by the EIB; therefore, due to the lack of regulations, EIA is unable to presently require control of the existing emission sources.

   Communication with the EIA staff indicates that they, (EIA), hope to begin work to develop air emission regulations for the potash industry before January 1, 1976.

As noted previously, the air emission calculations made for this report indicate 4 of the existing potash refineries are exceeding the state's annual ambient air standards for particulate material.

2. The lessee shall not operate new refining equipment which produces air emissions having an opacity of greater than 20 percent.

   This limit does not apply to uncombined water and an opacity of greater than 20 percent but less than 40 percent will be acceptable for not more than 2 minutes in one hour. Opacity is defined as the degree to which emissions reduce the transmission of light or obscure the view of an object in the background. (R)

   > In the case of existing potash refining facilities, the BLM recognizes that some lessees have invested large sums of capital in equipment which cannot be readily controlled to meet the above standards. Rather than developing a standard which would require arbitrary removal of this equipment, we believe this situation is best handled via adjudication and negotiation associated with the New Mexico Environmental Improvement Board (EIB) regulation procedure. At the present time there are no standards on opacity; however, we believe it is necessary to limit the opacity of emissions to protect the aesthetics. Accordingly, it is proposed that the state enact adequate emission regulations by 1985. If adequate emission regulations are not enacted by 1985, the BLM reserves the right to review the visual pollution situation and set necessary opacity standards.
   >
   > Note: The EIB process involves EIA staff work, including consultations with industry and concerned citizens, EIB public hearings on proposed regulations and EIB establishing regulations based on information presented at the hearings; these regulations would call for the necessary control to meet the standards.

3. When developing a mine, transport any removed waste material to an existing or designated refinery tailings site by a method which minimizes fugitive dust. During transportation and storage of ore and finished product, employ measures which will create a minimum of fugitive dust. (MR)

4. The lessee or permittee may be required to convert certain potash exploration drill holes into water or brine wells. The

conversion will be done in a manner approved by the Area Mining Supervisor and the lessee or permittee will be reimbursed for the cost of conversion which exceeds the normal cost of abandonment of the well. The government will assume the responsibility for subsequent proper plugging and abandonment of the well. (E)

5. The lessee shall provide accurate measurements of the amount and quality of water flowing into their refinery and the amount and quality of the water or brine flowing from their refinery. (R)

6. Drill holes will be properly sealed through water-bearing aquifers according to applicable procedures and regulations. Shafts will be properly grouted and sealed through water-bearing aquifers. Where shaft seals cannot be made completely effective, shaft rings and/or sumps with adequate pumps will be installed where necessary and fluids will be pumped to the surface and disposed in a manner consistent with applicable procedures and regulations. (EM)

7. Scientific studies including geologic and hydrologic studies shall be made by the lessee prior to the siting and construction of brine ponds. If these studies indicate the site is located where there may be significant environmental damage from leakage, ponds shall be sealed. (R)

8. If it is determined that potash refinery effluents are polluting valuable groundwater or causing pollution of the Pecos River the lessee shall take action to seal the source of pollution or employ other appropriate means to correct the problem. (R)

9. Design and manage tailings piles to provide for an optimum balance of maximum evaporation, a minimum combined area of tailings piles and brine ponds, and maximum possible blending with the adjacent landscape. (R)

10. All tailings ponds should be designed and constructed to contain all effluent and to control floodwaters. Where feasible, a dike should be constructed around the edge of waste disposal areas to restrict the flow of runoff. (MR)

11. As a general rule the lessee shall not dispose of refinery waste material into natural lakes and playas; exceptions will

be based on specific studies to determine the least environmental impact. (R)

12. The Lessee or Permittee shall minimize surface disturbance when conducting exploration and mining activities. (EM)

13. Common use corridors should be considered when planning utility and transportation facilities, and existing roads shall be used whenever possible. (EMR)

14. All roads (including culverts, turnouts, ditches, and waterbars) will be constructed, as a minimum, according to BLM standards. (EMRA)

15. The Lessee or Permittee shall haul all trash to authorized sanitary landfills. Other methods of disposal should be by special permit or approval. (EMRA)

16. Topsoil will be stockpiled and replaced on disturbed areas in a manner provided by the approved Exploration or Mining and Reclamation Plan. (EMR)

17. Where excavation is required for support facilities, all trenches will be backfilled, and a berm will be left on top of the backfill adequate to compensate for settling. (EMR)

18. An existing refinery should be utilized wherever possible to process new ore deposits. If a new refinery is required, it is preferred that an existing refinery site be utilized. (R)

19. Surface of the lease areas shall be abandoned only after rehabilitation or reclamation of disturbed areas to BLM specifications and time frames. Rehabilitation may require scarification and treatment of specified areas with fresh water to leach toxic salt accumulations from the active root zone of the soil. (A)

20. Wherever possible locate mines, refineries and all support facilities (roads, highways, pipelines) such that the pillar necessary to support the operation does not infringe upon the potash ore deposit. (MR)

21. Where refining facilities are located over mineable ore and these facilities are removed, the mineable ore will be extracted prior to the removal and abandonment of the hoisting system. (MRA)

Mitigating measures recommended but not normally required of a permittee or lessee

22. The permittee or lessee shall allow the government to tap into waterlines and provide water free of charge for wildlife in order to replace wildlife productivity lost through potash operations. (MR)

23. Removal of trees which are used now or could be used in the future for raptor nesting or perching will be avoided. If alternatives are not feasible, mitigation measures will include the replacement of trees in like kind and number with a survival rate over a 5 year period of 100 percent in the case of single trees and 80 percent in relation to groups or stands. The location of the mitigation will be determined by the District Manager. (EMR)

24. The location of facilities within 300 yards of tree groves or other known raptor nesting areas will be avoided. If alternatives are not feasible, mitigation in the form of habitat replacement of comparable value will be required. This mitigation may be in the form of man-made structures or replacement tree plantings at the discretion of the District Manager Location and survival (if applicable) will be determined by the District Manager. (EMR)

25. If bird electrocutions become a problem on segments or specific poles of existing transmission or distribution lines, modifications of the poles will be made according to specifications in R.E.A. Bulletin 61-10. Such modifications will be made without liability or expense to the United States. When powerlines are abandoned, a designated number of poles should remain in place for use by raptors and other large birds. (MRA)

26. All new powerlines will conform to specifications in R.E.A. Bulletin 61-10. When powerlines are abandoned, a designated number of poles should remain in place for use by raptors and other large birds. (MRA)

27. Prior to location of mine shafts, refineries, salt tailings piles, and brine ponds, studies shall be conducted by the lessee to determine minimum buffer area necessary to protect wildlife habitat and cultural resources. If studies indicate that the proposed location of facilities does not provide a minimum buffer, measure will be taken to mitigate the impacts or the proposed site location may have to be moved. These studies shall be conducted as part of the development of the mining plan. (MR)

Mitigating measures recommended but not normally required of a permittee or leasee :

Mitigating Measures

28. Prior to any surface disturbing activity, an archaeological survey will be conducted by an archaeologist certified by USDI. The survey shall meet BLM archaeological specifications. All costs shall be borne by the permittee or lessee. (EMRA)

29. All identified archaeological sites will be:

A. Avoided by surface disturbing activity; or with written approval of BLM,

B. Salvaged by an archaeologist certified by USDI prior to surface disturbing activities as directed by BLM. (EMRA)

30. In the event that archaeological materials are encountered during surface disturbing activities, operations will cease, the BLM District Manager will be notified and operations will not continue until approval to proceed is granted. (EMRA)

31. When planning and constructing mining, refinery or support facilities, the lessee shall apply the principles of landscape architecture, guided by the applicable current BLM Visual Resource Management System. The lessee shall submit elevation drawings as part of the mining plan for written approval. (EMR)

32. Any new headframes will be painted a drab non-reflective color, unless waived. Any request for waiver shall be submitted with the Mining Plan proposing the new headframe. (M)

33. The lessor reserves the right to add future stipulations to protect other resources including but not limited to the surface estate and groundwater quality. (EMRA)

34. All references to regulations, standards, bulletins, specifications, manuals, etc., refer to those regulations, etc., now or hereafter in effect. (EMRA)

b. Mitigating measures of a general nature requiring the cooperation of industry and government.

35. An interpretive facility should be provided to explain to the public what the industry is and why it is necessary. An appropriate location would be along U. S. Highway 62-180. (MR)

36. Initiate an air quality monitoring program for the potash Study Area. (R)

37. Establish a research project to determine the environmental effects of slimes, solid salt, and brine tailings, and develop ameliorating procedures. This would include a monitoring program of aquifers and water movement to determine the extent and effects of waste water percolation into aquifers. (R)

38. Conduct research to find new or improved methods of refining and brine disposal to reduce the consumption of water. (R)

39. Initiate a new hydrologic study of Anderson Lake and Laguna Grande de la Sal. (R)

40. A comprehensive plan for a mineral resource inventory and simultaneous or sequential development of potash and oil/gas yield should be formulated in order to minimize environmental impacts and maximize yields. (EM)

41. Conduct Research Into Improved Mining Techniques to Increase Recovery of Additional Ore. (M)

42. Create an Adjustable Royalty Procedure Based on Potash Ore Grade and Overriding Royalty to Provide Incentive to Use Lower Grade Ore. (MR)

43. Studies should be made to determine the most feasible method of recovering potash entrained in refinery effluent and industry should be encouraged to recover it. (MRA)

44. Conduct research into new or improved refining techniques to recover more potash, and possibly magnesium to reduce waste of minerals. (R)

45. Investigate new markets for salt and encourage a freight rate structure which is more beneficial for transporting salt. (R)

46. Conduct studies to determine the suitability and habitability of natural lakes, playas, and brine ponds to wildlife (terrestrial and aquatic) and develop ameliorating procedures. (MRA)

47. If it is decided that the potash companies should monitor the environment With company personnel, a training course should be given by the appropriate government agencies on techniques of environmental monitoring. The techniques of

making and reporting chemical analyses should be standardized to a reasonable extent. Those government agencies receiving the data should understand the limitations of methods Used to Acquire it. (MR)

c. Possible mitigating measures which are not recommended.

48. It has been suggested that the salt tailings could be returned underground and disposed of in the voids created by mining. (MRA)

This mitigating measure is not recommended because traditionally, mine tailings are reworked once or twice to recover valuable minerals that were missed in the first or second processing.

The present method of room and pillar mining does not easily accommodate a scheme for refilling the voids left with salt tailings. If the rooms were to be refilled, the pillars probably could not be mined thus additional potash would be lost in the mining process. Moreover, the voids left are of sufficient volume to receive and store the mine tailings. Finally, this measure is economically unfeasible.

49. If studies show refinery effluents are polluting the Pecos River or increasing the amount of brine flow from the natural salt springs at Malaga Bend, the potash companies should pump an equivalent amount of brine from the aquifer feeding the springs at Malaga Bend into Laguna Grande de la Sal. (R)

Many hydrologist familiar with the hydrologic problems at Malaga Bend have long advocated some variation of this mitigating measure and it is admitted that this may be a practical solution to alleviating the salinity of the Pecos River in the reach from Malaga Bend to Red Bluff Reservoir; however, there are numerous difficulties with this scheme. First, Laguna Grande de la Sal is privately owned, and it is doubtful if the owners (MCC) can be persuaded to allow additional pumpage of brine into this reservoir.

Secondly, Laguna Grande de la Sal also contains valuable archaeological sites and if used as a respository for brine the lake levels must be maintained below former high levels. It is possible that this reservoir could be used to store additional brine with little increase in reservoir level if additional salt is harvested from the lake floor.

A further reason for not recommending this measure is that if the reservoir stages were raised the lake may leak.

50. The government should assess a fee for each ton of finished product, with the money raised by this assessment to be used for reclamation and rehabilitation of the land disturbed by potash mining and refining. (MRA)

This is considered to be a desirable mitigating measure; however, it is outside of the authority of the agencies regulating potash leasing and mining. The implementation of this measure would require congressional action.

51. Technically it is possible to require the production of lower grade K_2O finished product so as to improve total potash recovery and consume less fresh water in the refining process. (MR)

This mitigating measure may be desirable; however, it is not within control of the Department of Interior because product quality is a function of the market.

d. Mitigating measures on health and safety under the specific authority of MESA. There appears to be adequate regulations and/or authority for MESA to implement the following type of mitigating measure.

52. Conduct an extensive evaluation of in-plant and underground dust contamination levels. Provide an adequate respirator control and monitoring program. (MR)

53. Implement a noise exposure survey program and a hearing conservation program with intensive control and monitoring. (MR)

The implementation of the general mitigating measures requiring the cooperation of industry and government is somewhat questionable. This is because no single agency has the authority to require participation by the organization which must cooperate in this implementation.

Relative to air quality, the New Mexico Environmental Improvement Agency has established an air quality monitoring station in the potash Study Area. This single station does not fulfill the total need for air monitoring; however, it is a step in the right direction.

The letter on page III-63 from the EIA indicates their intention to commence work on developing air emission regulations for the potash industry.

HEALTH SAFETY WELLBEING COMFORT
STATE OF NEW MEXICO
Environmental
Improvement
Agency
P.O. Box 2348, Santa Fe, New Mexico 87503

AIR QUALITY DIVISION

October 3, 1975

Mr. Bob Schmidt
Bureau of Land Management
U.S.Department of the Interior
P.O. Box 1449
Santa Fe, New Mexico 87501

Dear Mr. Schmidt:

May I offer the following in regard to your request for information concerning the status of possible air pollution control regulations for the potash industry. Our Program Development and Planning Section will be investigating the effects of potash emissions on the ambient air, as well as the technology and economics of control of the emissions, within the next several months.

The analysis to date indicates that a number of the potash mills may have a rather severe impact on the ambient air. We would hope that proposed regulations could be drafted by the end of 1975. With the Environmental Improvement Board's permission, hearings could be held on proposed regulations early in 1976.

Sincerely,

Cubia L. Clayton
Chief

CLC:elc

To the extent money and manpower are available, BLM will place a hydrologist in the Roswell District Office and support the project with adequate funds to implement the necessary ground water monitoring and evaporation studies.

The remaining mitigating measures requiring cooperation, deal principally with research efforts, planning efforts and administrative procedures to gain information and improve potash recovery. The exception to this is the proposal to establish an interpretive facility to explain the potash industry. Failure to implement these mitigating measures due to an inability to achieve the required cooperation or funding may possibly result in a slightly greater environmental impact than has been anticipated in the residual impact section of this analysis. Tourists may have a more negative impression of the potash industry's impact on the aesthetics if the interpretive center is not established. Also the possible benefits from the proposed research and planning would not materialize.

In the course of making this analysis, information has been developed which sheds some light on problems and environmental trade offs associated with mitigating the environmental impacts of the air emissions and the effluent discharge from the potash industry.

e. Mitigation Measures for Air - Elaboration

The basic mitigation measure for air quality improvement is that particulate control equipment should be installed so as to reduce the emissions from the refineries to the extent that all refineries meet the applicable ambient air quality standards. Three levels of standards are considered - - the maximum 24-hour average, the 30-day average, and the annual geometric mean. The basis for determination of additional percentage reductions at each refinery was as follows:

1. For the maximum 24-hour average (standard = 150 ug/m^3) - - reduce the 24-hour maximum from each refinery to 105 ug/m^3 so that if a background of 40 ug/m^3 is considered. The total concentration would be 5 ug/m^3 less than the standard (145 ug/m^3 compared to 150 ug/m^3).

2. For the 30-day average (standard 90 ug/m^3) - - reduce the 30-day average for the peak month (June) from each refinery to 45 ug/m^3 so that if a background of 40 ug/m^3 is considered, the total concentration would be 5 ug/m^3 less than the standard (85 ug/m^3 compared to 90 ug/m^3).

3. For the annual geometric mean (standard = 60 ug/m^3) - - reduce the peak annual concentration from each refinery to 15 ug/m^3 so that if a background of 40 ug/m^3 is considered, the total concentration would be 5 ug/m^3 less than the standard (55 ug/m^3 compared to 60 ug/m^3).

On the above basis, Table III-4 shows the particulate controls that would be required to meet the 3 levels of standards. If the 30-day standard is met, an overall reduction of 50 percent would be required; however, the 24-hour maximum and the annual geometric mean standards would not be met. An overall reduction of 71 percent would assure compliance with the 30-day and annual standards; however, the 24-hour maximum standard would not be met. An overall reduction of 91 percent would assure compliance with all 3 standards.

Emission Control Technology

Control technology is available for removing particulates from gas streams. (National Air Pollution Control Administration, 1969).

Table III-4 1: RECOMMENDED PARTICULATE CONTROLS

Plant	1975 Emissions (tons/yr)	To Meet Annual Standard		To Meet 30-Day Standard		To Meet 24-Hour Maximum Standard	
		Rec. % Reduction	1978 Emissions (tons/yr)	Rec. % Reduction	1978 Emissions (tons/yr)	Rec. % Reduction	1978 Emissions (tons/yr)
National	128	0	128	0	128	0	128
Duval	2,660	52	1,277	9	2,421	89	293
AMAX	2,629	70	789	38	1,630	95	131
Miss Chem*		(unknown)		(unknown)		82**	
Kerr McGee	470	0	470	0	470	0	470
PCA	4,084	80	817	63	1,511	95	204
IMC	9,562	77	2,199	62	3,634	95	478
TOTAL	19,533		5,680		9,794		1,704
Overall % reduction		71		50		91	

* Not included since the data are not sufficient for calculation for the proposed new Mississippi Chemical plant.

** For existing MCC plant.

The collection of particles from the gas stream involves deposition on a collecting surface, retention, and removal from the surface. To enable deposition there is a need for a resultant force upon the particle in the direction of the collection surface. There are 6 mechanisms by which this force may be imparted to a particle to cause it to migrate toward a collecting surface, or to cause it to be directly intercepted. These six mechanisms are: 1) gravity, 2) centrifugal force, 3) inertial impaction, 4) direct interception, 5) diffusion, and 6) electrostatic. The predominance of one of these six mechanisms depends on the particle size and the collection device. A summary of the mechanisms of collection and the effectiveness of various particulate collectors is contained in Table III-5. (American Industrial Hygiene Association) It should be noted that each collector has a characteristic size-efficiency curve such as that shown in Figure III-1 for a cyclone. For the cyclone under the conditions as shown in Figure III-1, particles greater than 25 microns in diameter are removed with 100 percent efficiency, while those which are 5 microns in diameter are removed with a 72 percent efficiency. Table III-5 shows the particle size for which there is a 90 percent efficiency of removal for the collectors listed.

The gravity mechanism is based on the principle that if particles are large enough they will settle from a moving gas stream in a fairly short time. This mechanism is dominant only for particles greater than about 50 microns. The majority of the particulate emissions from potash refineries are less than 50 microns in size. The centrifugal force mechanism involves the rotation of the gas stream in a vortex flow, with the resultant centrifugal forces on the particles causing them to move from the gas stream to a collecting surface. The inertial impaction mechanism is based upon the inertial force of a particle which causes it to be removed from a gas stream when the gas stream is caused to diverge around an object. The concepts of inertial impaction, direct interception and diffusion are shown in Figure III-2. The direct interception mechanism is similar to inertial impaction except that the particle is caught on the object due to the finite width of the particle, even though the particle center would miss the object. The diffusion mechanism is important for sub-micron particles which are displaced by Brownian motion and, as a result, contact a collecting surface. Particles possessing an

Table III-5

FORCES INFLUENCING SMALL PARTICLE COLLECTION IN AIR POLLUTION CONTROL DEVICES

Class of Air Pollution Control Device	Force of Mechanism	Particle Diameter (microns)[1]
Settling Chamber	Gravity	50
Cyclone		
Large Diameter	Centrifugal + Impaction	25
Small Diameter	Centrifugal + Impaction	>5
Scrubber		
Spray Tower	Impaction + Direct Interception	25
Wet Cyclone	Impaction + Direct Interception + Centrifugal	5
Venturi	Impaction + Direct Interception + Centrifugal	1
Filter		
High Velocity Impingement	Impaction + Direct Interception	10
Bag or Screen Woven Fabric	Impaction + Direct Interception + Diffusion	<1
Reverse - Jet Felt	Impaction + Direct Interception + Diffusion	<1
Electrostatic Precipatator		
Single Stage High Voltage	Electrostatic	<1
Two Stage Low Voltage	Electrostatic	<1

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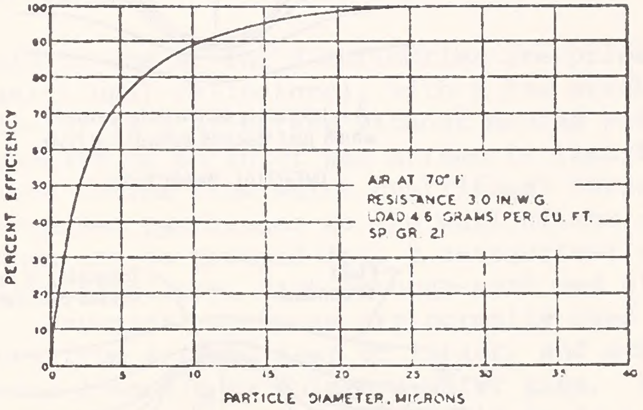
[1] Minimum Particle Size Collected at approximately 90% efficiency under usual operating conditions.

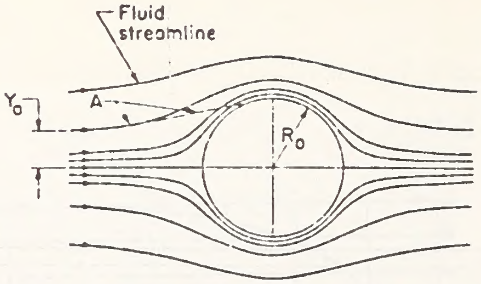
Figure III-1



Typical fractional efficiency curve of a cyclone.

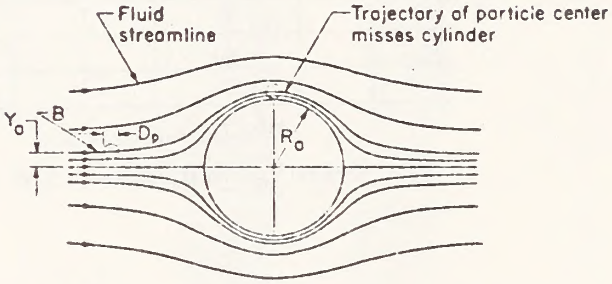
Reference: "Air Pollution Manual - Part II - Control Equipment", published by American Industrial Hygiene Association, Detroit, Michigan, 1968, p. 31

Figure III-2



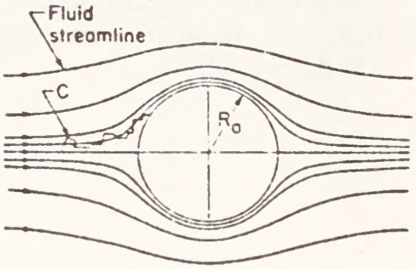
A is trajectory of particle center which just touches cylindrical fiber.

INERTIAL IMPACTION



B is trajectory of particle center and fluid streamline. Particle surface touches fiber at point of closest approach.

DIRECT INTERCEPTION



C is path of particle center due to fluid motion and random diffusion.

DIFFUSION

Figure 2· Mechanisms of mechanical filtration.

Ref: "Air Pollution Manual - - Part II - Control Equipment", published by American Industrial Hygiene Association, Detroit, Michigan, 1968, p. 14

electrical charge, either inherently or following inducement, can be removed from a gas stream upon passage through an electrostatic field.

The collectors in use at the 7 refineries are primarily cyclones (centrifugal collectors), with a few scrubbers. A cyclone collector is a structure without moving parts in which the velocity of an inlet gas stream is transformed into a confined vortex from which centrifugal forces tend to drive the suspended particules to the wall of the cyclone body. Cyclones can be grouped into 2 categories; conventional (medium efficiency, high through-put) and high efficiency. Convential cyclones are normally used singly, have diameters from 4 to 12 feet or larger, and exhibit pressure losses from 1/2 to 4 inches water gage. High efficiency cyclones are used either singly or in parallel group arrangements, have diameters of 3 feet or less, and exhibit pressure losses in the range of 2 to 8 inches water gage. A comparison of collection efficiencies is contained in Table III-6. One possibility for improving the collection efficiency at potash refineries is to use high efficiency cyclones, or perhaps cyclones in series.

Scrubbers (wet collectors) use a liquid, usually water, in the separation process either to remove particulate matter directly from the gas stream by contact or to increase collection efficiency by preventing re-entrainment. Many types of wet collectors are available, and as indicated in Table III-7, wet collectors can be classified on the basis of pressure drop into low, medium and high energy devices.

The simpliest type of washer is a tower with spray nozzles. Its overall efficiency is low. By installing baffles and subjecting the baffles to water sprays, the efficiency can be somewhat increased. In the wet cyclone, the dust laden gas enters tangentially and spirals through the scrubber in a continuously rotating path. In one type, sprays are located axially near the center of the scrubber with their nozzles directed radially toward the walls. The spray sweeps across the path of the gas stream intercepting and entrapping the dust particles. The centrifugal motion of the spray imparted by the rotating causes the droplets to impinge against the washer walls and then drain to the bottom by gravitation. In another type, the spray nozzles are mounted on the wall and protrude into the washer. The advantage of this type is that any nozzle may easily be serviced or replaced.

Table III-6

COMPARISON OF CYCLONE EFFICIENCIES

Particle Size	Efficiency (% by Wt.)	
< 5	< 50	50 - 80
5 - 20	50 - 80	80 - 95
15 - 40	80 - 95	95 - 99
> 40	95 - 99	95 - 99

Table III-7

ENERGY CLASSIFICATION OF WET WASHERS

Type	Category
Spray Tower	Low Energy
Wet Cyclone	Low Energy
Venturi	Medium/High Energy

The venturi scrubber consists in principle of a "throat" and a divergent section. Dust laden gas enters the convergent section and is accelerated to high velocity as it approaches the throat. Water as scrubbing liquid is injected either directly into the throat section or the top of the venturi. The high velocity gas stream atomizes the liquid into a fine mist. Following passage through throat section, the gas flows into the divergent section for the purpose of reducing the velocity and collecting any entrained mist.

Scrubber design is largely empirical, and the selection of a given type of scrubber for a given need is largely based on a previously demonstrated satisfactory performance of that scrubber for that particular need. Several potash refineries are using scrubbers, and others are testing them for potential use. Therefore, another possible way for improving collection efficiency is to use scrubbers singly on stacks without controls, or to use scrubbers following cyclones.

Filter baghouses are often used in air pollution control, and they offer a potential alternative for potash refineries. A filter is any porous structure, compose of granular or fibrous materials, that possesses the ability to remove suspended matter from a fluid that is passed through it. Some type of fabric is the usual filter medium in air pollution control.

There are two basic types of fabric collectors; the compartmented bag collector and the uncompartmented bag collector. In the compartmented type the dust laden air enters the collector and passes through the inside of the bags where the dust is filtered out as clean gas passes through the bags and out of the system. The bags are self-supporting because the air is cleaned while flowing from the inside out. In the uncompartmented type, the dirty air enters the hopper, rises upward around the outside of the bags and passes through the fabric from the outside in. The dust collected on the outside surface of the bag and the clean gas passes upward through the inside, out an open end to an exhaust manifold.

An important factor in filter design is the selection of the fabric itself. Table III-8 contains a summary of filter fabric characteristics in relation to acceptable temperatures, combustibility, permeability, composition, resistance to physical and chemical degradation, and relative cost.

Table III-8 FILTER FABRIC CHARACTERISTICS

Fiber	Operating Exposure °F.		Supports Com-bustion	Air Perme-ability[a] cfm/ft^2	Composition	Resistance[b]				Cost[c] Rank
	Long	Short				Abrasion	Mineral acids	Organic acids	Alkali	
Cotton	180	225	Yes	10-20	Cellulose	G	P	G	G	1
Wool	200	250	No	20-60	Protein	G	F	F	P	7
Nylon[d]	200	250	Yes	15-30	Polyamide	E	P	F	G	2
Orlon[d]	240	275	Yes	20-45	Polyacrylonitrille	G	G	G	F	3
Dacron[d]	275	325	Yes	10-60	Polyester	E	G	G	G	4
Polypropylene	200	250	Yes	7-30	Olefin	E	E	E	E	6
Nomex[d]	425	500	No	25-54	Polyamide	E	F	E	G	8
Fiberglass	550	600	Yes	10-70	Glass	P-F	E	E	P	5
Teflon[d]	450	500	No	15-65	Polyfluoroethylene	F	E	E	E	9

[a] cfm/ft.^{2} at 0.5 in. W.G.

[b] P = Poor, F = Fair, G = Good, E = Excellent.

[c] Cost Rank, 1 = lowest cost, 9 = highest cost.

[d] Dupont registered trademark.

(National Air Pollution Control Administration, 1969.) In spite of the fact that the hygroscopic nature of potash refinery particles could cause operational difficulties with filters, they do appear to be a good collector for potential use in series following a cyclone.

Electrostatic precipitators utilize electrostatic forces to separate suspended particles from gas streams. Three fundamental steps are required in order to achieve separation; they are, 1) electrical charging of suspended particles, 2) collection of the charged particles in an electrical field, and 3) removal of the collected material from the collecting electrodes to a receptacle external to the precipitator. Electrostatic precipitators have 2 electrodes, a high-voltage discharge electrode and a collecting-ground electrode. As particles pass through the electrostatic field they become negatively charged by the bombardment of electrons. Once the particles are charged, they move toward the collecting electrode due to Coulombs' law. Although precipitators have been used extensively for air pollution control, they have not been used in the potash industry.

Costs of Particulate Control

One of the primary considerations in air pollution control is related to the costs, both initially as well as for annual operation and maintenance. The majority of the information to be presented in this section is from a 1969 "state-of-the-art" report prepared by the National Air Pollution Control Administration, a precursor agency to the Environmental Protection Agency. It is recognized that the absolute cost figures have changed since they were developed in 1968, however, on a relative basis for various collectors, cost comparisons are still useful. The costs data presented herein were developed following a study of the literature, and a survey of more than 250 suppliers, users, installers, and operators of air pollution control equipment.

Purchase costs for cyclones, scrubbers and baghouses are shown in Figures III-3, III-4, and III-5, respectively. Low efficiency refers to 75 percent removal, medium efficiency to 90 percent and high efficiency to 99 percent removal. The typical flows in the majority of the stacks at the 7 potash refineries range from 5,000 to 25,000 actual cubic feet per minute (acfm), with an average value of 18,200 acfm. For a flow of 20,000 acfm, the purchase costs from Figures III-3, III-4 and III-5 are as follows:

Figure III-3

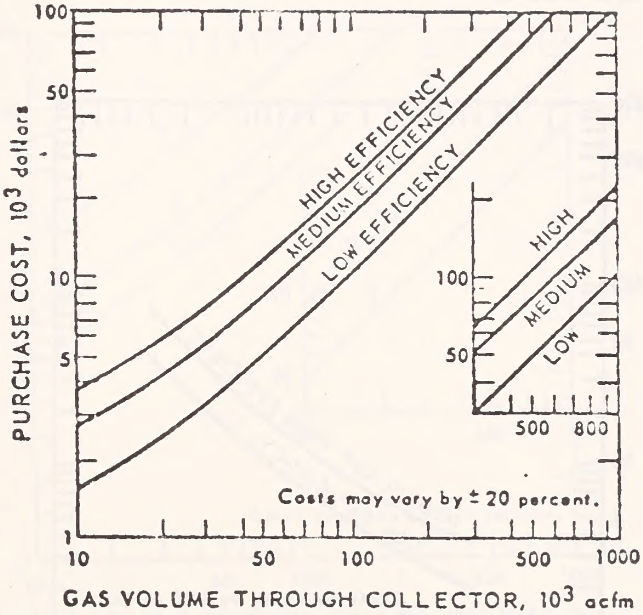


FIGURE Purchase cost of dry centrifugal collectors (cyclones)

Ref: "Control Techniques for Particulate Air Pollutants", National Air Pollution Control Administration, Publication No. AP-51, January, 1969, p. 171

Figure III-4

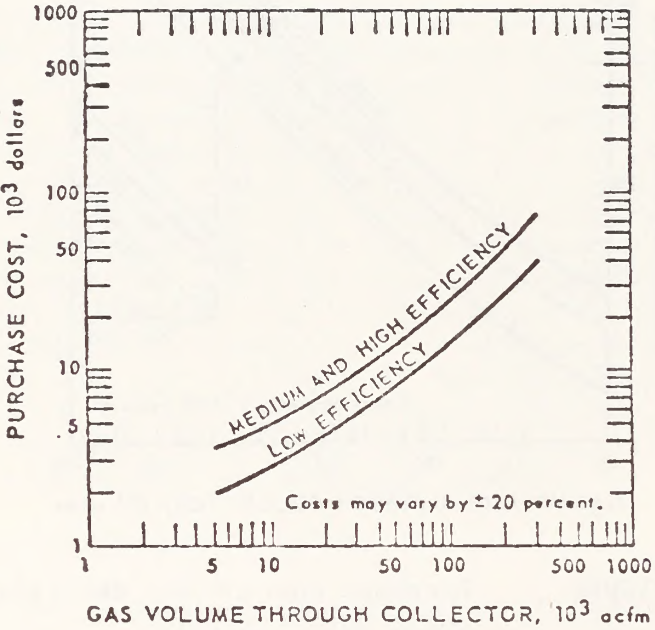


FIGURE Purchase cost of scrubbers.

Ref: "Control Techniques for Particulate Air Pollutants," National Air Pollution Control Administration, Publication No. AP-51, January, 1969 p. 172.

Figure III-5

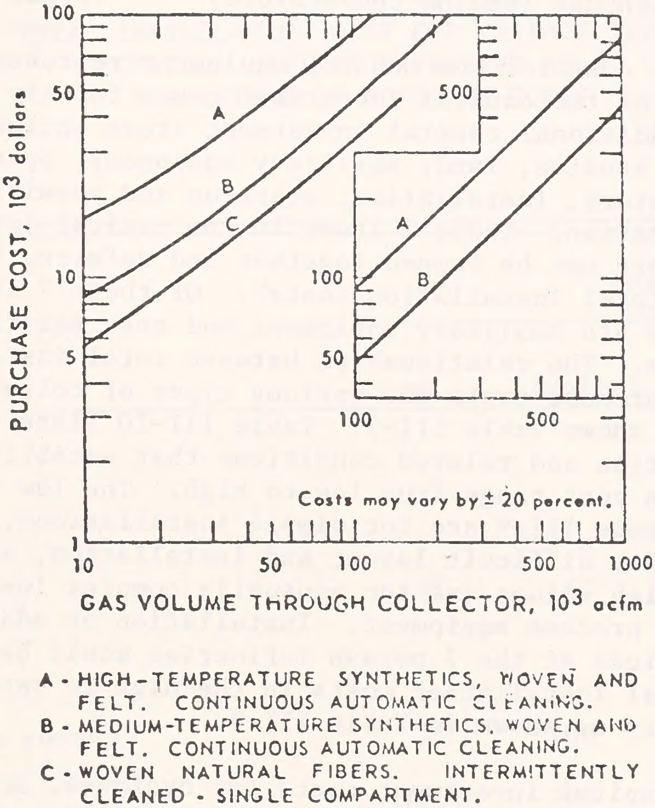


FIGURE Purchase cost of baghouses.

Ref: "Control Techniques for Particulate Air Pollutants," National Air Pollution Control Administration, Publication No. AP-51, January, 1969, p. 174

Medium efficiency cyclone	$4,000
High efficiency cyclone	6,000
High efficiency scrubber	7,000
Baghouse (medium temperature)	12,000

The purchase cost for the control equipment represents only one portion of the capital investment costs for air pollution control. Additional capital investment items include engineering studies, land, auxiliary equipment, operating supply inventory, installation, start-up and possible structure modification. These 7 items in the capital investment costs category can be lumped together and referred to collectively as "total installation costs". Of these 7 items, the 2 major ones are auxiliary equipment and cost for field installation. The relationships between total installation costs and purchase costs for various types of collection devices are shown Table III-9. Table III-10 lists the major cost categories and related conditions that establish the installation cost range from low to high. The low values listed in Table III-9 are for simple installations, the high values are for difficult layout and installation, and the extremely high values are for unusually complex installations on existing process equipment. Installation of additional control devices at the 7 potash refineries would be expected to have total installation costs in the high to extremely high category as shown in Table III-9.

The total capital investment costs for cyclones, scrubbers and baghouses are shown in Figures III-6, III-7, and III-8, respectively. (National Air Pollution Control Administration, 1969.) The total capital investment cost is referred to in these figures as the "installed cost". For a flow of 20,000 acfm, the installed cost for particulate control equipment in use, or potentially usable, in potash refineries, is as follows:

Medium efficiency cyclone	$6,000 - $8,000
High efficiency cyclone	8,000 - 11,000
High efficiency scrubber	12,000 - 40,000
Baghouse (medium temperature)	18,000 - 25,000

If it is assumed that 1975 installed costs for particulate control equipment are double those reported for 1968 as above, and considering the air pollution control equipment "in place" in 1975 at the 7 potash refineries (Table II-44, p. 58, this represents a total investment of more than $1.1 million (using 20,000 acfm as average flow and upper limit of cost range).

TABLE III-9

TOTAL INSTALLATION COST FOR VARIOUS TYPES OF CONTROL DEVICES EXPRESSED AS A PERCENTAGE OF PURCHASE COSTS

Equipment Type	Cost, Percent			
	Low	Typical	High	Extreme High
Cyclone	35	50	100	400
Scrubber				
Low, medium energy	50	100	200	400
High energy[1]	100	200	400	500
Baghouse	50	75	100	400

---

[1] High-energy wet collectors usually require more expensive fans and motors.

TABLE III-10

CONDITIONS AFFECTING INSTALLED COST OF CONTROL DEVICES

Cost Category	Low Cost	High Cost
Equipment transportation	Minimum distance; simple loading & unloading procedures.	Long distance; complex procedure for loading and unloading.
Plant age	Hardware designed as an integral part of new plant.	Hardware installed into confines of old plant requiring structural or process modification or alteration.
Available space	Vacant area for location of control system.	Little vacant space requires extensive steel support construction and site preparation.
Corrosiveness of gas	Noncorrosive gas	Acidic emissions requiring high alloy accessory equipment using special handling and construction techniques.
Complexity of startup	Simple startup, no extensive adjustment required.	Requires extensive adjustments; testing; considerable down time.
Instrumentation	Little required	Complex instrumentation required to assure reliability of control or constant monitoring of gas stream.
Guarantee on performance	None needed	Required to assure designed control efficiency.
Degree of assembly	Control hardware shipped completely assembled.	Control hardware to be assembled and erected in the field.

TABLE III-10 continued

Cost Category	Low Cost	High Cost
Degree of engineering design.	Autonomous "package" control system.	Control system requiring extensive integration into process, insulation to correct temperature problem, noise abatement.
Utilities	Electricity, water, waste disposal facilities readily available.	Electrical and waste treatment facilities must be expanded, water supply must be developed or expanded.
Collected waste material handling.	No special treatment facilities or handling required.	Special treatment facilities and/or handling required.
Labor	Low wages in geographical area.	Overtime and/or high wages in geographical area.

Figure III-6

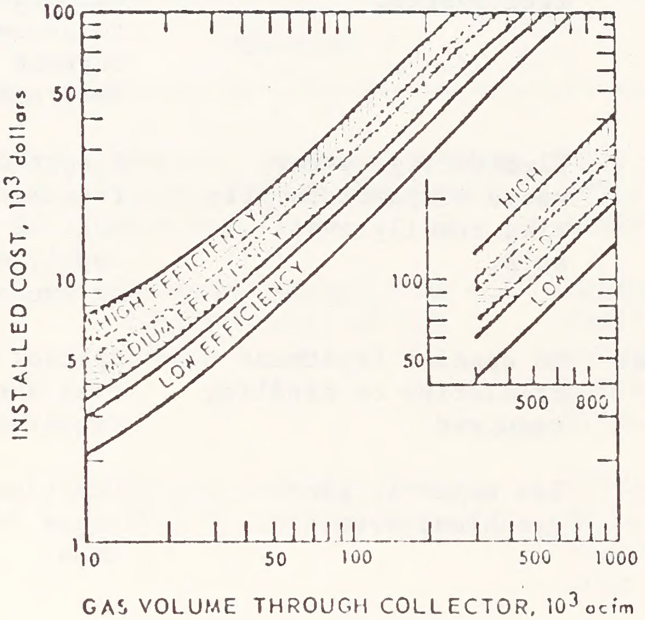


FIGURE Installed cost of cyclones.

Ref: "Control Techniques for Particulate Air Pollutants," National Air Pollution Control Administration, Publication No. AP-51, January, 1969, p. 171.

Figure III-7

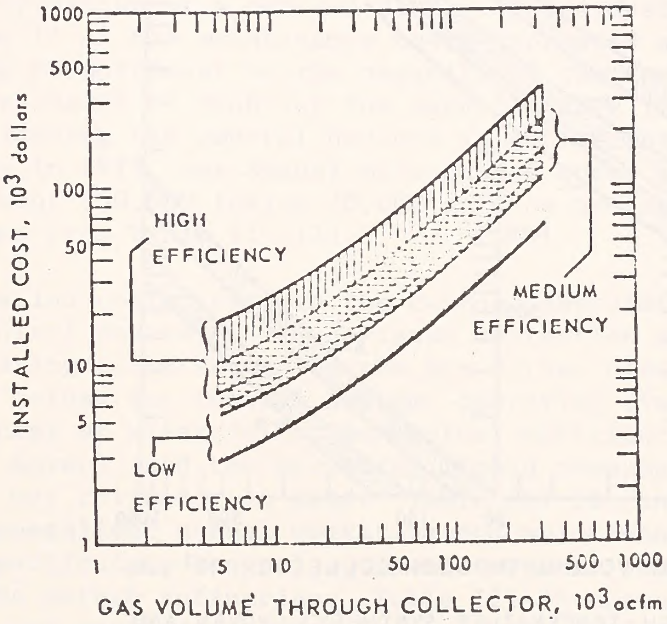


FIGURE Installed cost of scrubbers

Ref: "Control Techniques for Particulate Air Pollutants," National Air Pollution Control Administration, Publication No. AP-51, January, 1969, p. 172.

Figure III-8

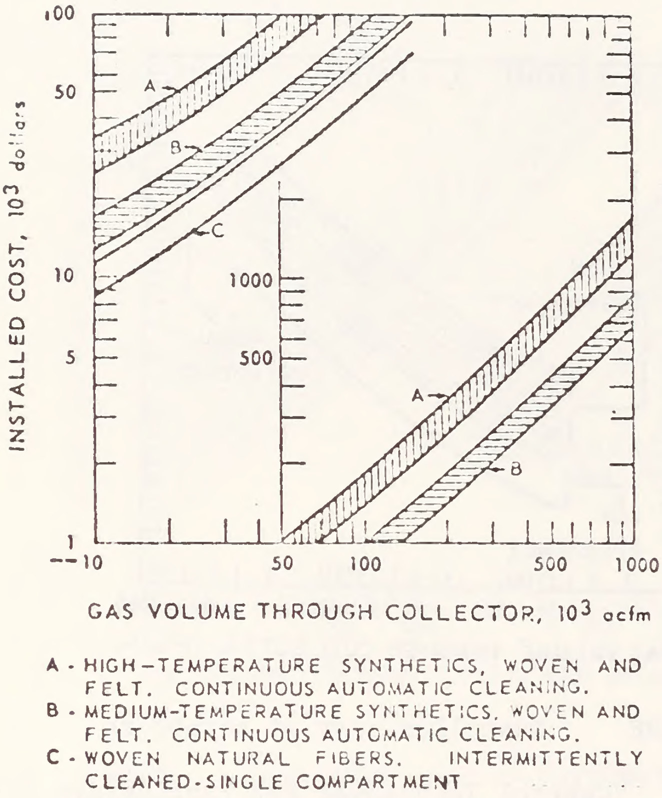


FIGURE Installed cost of baghouses.

Ref: "Control Techniques for Particulate Air Pollutants," National Air Pollution Control Administration, Publication No. AP-51, January, 1969, p. 175

The annual maintenance and operation costs for controlling particulate emissions may represent a sizeable fraction of the total annual costs for air pollution control. Maintenance costs are considered as the expenditures required to sustain the operation of a control device at its designed efficiency. Table II-11 has maintenance costs expressed on the basis of being proportional to the capacity of the device in action. On the basis of doubling the data in Table III-11, and considering the control devices in use at the potash refineries in 1975, the annual maintenance costs are estimated to be about $50,000 (using 20,000 acfm as average flow and high values from Table III-11).

Operation costs refer to the expense associated with operating a control device at its designed collection efficiency. Operating costs depend on the gas volume cleaned, the pressure drop across the control system, operating time, consumption and cost of electricity, mechanical efficiency of the fan (air mover), and the scrubbing liquid consumption and costs if a wet collector is used. Table III-12 contains a summary of generalized annual operating and maintenance cost equations for particulate control equipment used or potentially usable in the potash refineries. Table III-13 contains various cost and engineering factors necessary for use in the equations specified in Table III-12. Using the equations in Table III-12, and the highest values for the various costs and engineering factors in Table III-13, the annual operation and maintenance costs for a cyclone is about $6,500 (based on an average flow of 20,000 acfm and doubling the 1968 cost factors). The comparable costs for a wet scrubber and filter baghouse are $86,000 and $14,000 respectively. Considering the total number of cyclones and scrubbers in use at the 7 potash refineries, the total annual operation and maintenance expenditures for air pollution control in 1975 will exceed $650,000.

The annualized capital costs for air pollution control represents the sum of the annual depreciation on the capital investment plus the annual maintenance and operation costs plus the annual capital charges. In order to calculate annualized capital costs for the potash industry the following assumptions are made: (1) the installed costs are depreciated over 15 years by the straight-line method, thus yielding a cost of 6 2/3 percent of the installed cost per year (15 years is considered to be the feasible economic life of particulate collection devices), and (2) the capital charges

Table III-11

ANNUAL MAINTENANCE COSTS FOR GENERIC TYPES OF CONTROL DEVICES (1968 data)

Generic Type	Dollars per acfm		
	Low	Typical	High
Cyclones	0.005	0.015	0.025
Scrubbers	0.02	0.04	0.06
Baghouses	0.02	0.05	0.08

TABLE III-12

GENERALIZED ANNUAL OPERATING AND MAINTENANCE COST EQUATIONS FOR CONTROL EQUIPMENT

Collector	Generalized equation
Cyclone	$G=S\left[\frac{0.7457\ PHK}{6356\ E}+M\right]$
Scrubber	$G=S\left[0.7457\ HK\left(Z+\frac{Qh}{1980}\right)+WHL+M\right]$
Baghouse	$G=S\left[\frac{0.7457\ PHK}{6356\ E}+M\right]$

Where:

G = annual costs, dollars, for operating and maintenance.
S = design capacity of the unit, actual cubic feet per minute (acfm).
P = pressure drop, inches of water.
H = hours of operation annually.
K = cost of electricity; dollars per kilowatt-hour.
E = fan efficiency expressed as decimal.
M = maintenance cost per acfm, dollars per cfm. (from TABLE).

W = make-up liquid rate in gallons per hour per acfm.
L = cost of liquid in dollars per gallon.
Z = total power input required for a specified scrubbing efficiency, horsepower per acfm.

h = elevation for pumping of liquor in circulation system for collector, feet.
Q = water circulation, gallons per acfm.

TABLE III-13

MISCELLANEOUS COST AND ENGINEERING FACTORS

(Fan efficiency E = 60 percent; Pump efficiency = 50 percent)

K = Power cost, dollars/kw-hr[1]

	Low	Typical	High
All devices	0.005	0.011	0.020

H = Hours of operation, 8760 hours per year, 24 hr/day x 365 days/yr + 8760

	Low	Typical	High
L = Liquor cost in 10^{-3} dollars per gallon per hour (for wet system) -- Wet scrubber (make-up liquor requirements, W = 0.05-5 gal/hr-acfm)	0.35	0.50	1.00

Power requirements

	Low Efficiency	Medium Efficiency	High Efficiency
Z = "Scrubbing" (contact) power, horsepower/acfm	0.0013	0.0035	0.015

Scrubber liquor data

	Low	Typical	High
Q = Liquor circulation rate, gal/acfm	0.001	0.008	0.020
h = Minimum head requirements, feet water	1[2]	30	60

P = Pressure drop through equipment, inches of water

Generic type	Low	Typical	High
Cyclone	--	2-3	4
Fabric filter	2-3	4-5	6-8

---

[1] Based on national average of large consumers.

[2] 1 psig = 2.3 ft. water

are equal to the amount of depreciation. Capital charges include taxes, insurance, interest, and other items. Based on these assumptions, the annualized capital costs for air pollution control at the 7 potash refineries is in excess of $800,000, or about $0.20 per ton of potash produced.

A summary of the particulate collectors in use at the 7 potash refineries, and their anticipated effectiveness and energy requirements are shown in Table III-14. In addition, Table III-14 also shows the estimated number of additional collectors required to meet the various ambient air quality standards shown in Table III-4. In order to meet the 30-day standard, an estimated 25 additional high-efficiency cyclone would be required, to meet the annual standard would require 5 more high-efficiency cyclones and 8 secondary cleaners such as scrubbers or baghouses; and to meet the 24-hour standard would require 17 more secondary cleaners. The estimated additional annualized capital costs for meeting these standards are as follows:

30-day standard
$25,000

Annual standard
$750,000

24-hour maximum
$1,750,000

The total annualized capital costs would become as follows:

30-day standard
$1,050,000 ($0.25 per ton of final product)

Annual standard
$1,550,000 ($0.37 per ton of final product)

24-hour maximum
$2,550,000 ($0.61 per ton of final product)

In summary regarding particulate control technology for reducing emissions from potash refineries, cyclones, scrubbers and baghouses, when properly designed either singly or in series, offer potential alternatives for satisfying many needs. A review of available information indicates that economical air emission control technology is lacking for Ozark evaporators.

Table III-14 Particulate Control in the Seven Potash Refineries

Type of Control Device	Number in Use at Current Time	Effectiveness of Particulate Control Devices*			Relative Energy Requirement**	Additional Control Devices Required to Meet Standards		
		Small Particles	Medium Particles	Large Particles		30-Day (50% overall reduction)	Annual (71% overall reduction)	24-Hour (91% overall reduction)
Medium-efficiency cyclone	12			Good	0.5			
High-efficiency cyclone	25		Good		1	25	30	30
Scrubber	5	Good			10		8	25
Baghouse	0	Good			2			

*Small particles are less than 5 microns in diameter, medium particles are from 6 to 25 microns, and large particles are greater than 25 microns in diameter. In general potash refinery stocks without any control devices emit small, medium, and large particles.

** Based on assigning a relative value of 1.0 to the high-efficiency cyclone.

f. Mitigating Measures for Water - Elaboration

Characteristics and treatment of evaporation ponds

Studies by the U. S. Geological Survey at Malaga Bend provide data that can be used to estimate evaporation from the brine reservoirs associated with potash refining. Brine evaporation, as determined with a standard class "A" land pan for the calendar years 1964-68 is given in the following table (Linsley and others, 1958, p. 100):

Table III-15 EVAPORATION AT MALAGA BEND

Year	Evaporation (in feet)
1964	8.0
1965	5.9
1966	5.6
1967	6.5
1968	5.5
Average	6.3

These evaporation values apparently represent gross evaporation; therefore, net evaporation would be the difference between these values and annual precipitation (in feet).

To use these data for estimating lake evaporation, it is necessary to multiply the average annual area of the lake times the annual pan evaporation times a pan coefficient. It is difficult to estimate the pan coefficient because this value varies with conditions, but a value of 0.7 has been assigned for the data at Malaga Bend, and this value has been confirmed, more or less, by other independent methods of calculating evaporation. Using these data, the average annual evaporation from a lake with an annual average area of 100 acres would be:

$$100 \times 0.7 \times 6.3 = 441 \text{ acre feet.}$$

It can not be assumed that the difference between the inflow and evaporation values is the leakage. For example, if the lake with 441 acre feet of evaporation had a total inflow of 551 acre feet, but a gain in storage of 100 acre feet, the leakage would be zero.

The greatest difficulty in estimating the evaporation of disposal ponds is in estimating the annual average area.

The areas of these reservoirs range greatly with the season, being generally greater during the winter than during the summer. Some of the larger lakes are known to dry up during hot, dry summers.

It can be shown from chemical computations, that when a unit volume of saturated sodium chloride brine is evaporated, at least 14 percent of that unit volume of the lake's capacity is lost. This is because the salt in a liter or acre foot of the brine has a minimum dry volume of 0.14 liter or 0.14 acre foot. In fact, a larger percentage of the volume is lost because of the porosity of the precipitated salt. Therefore, if the precipitated salt has a porosity of 30 percent, it is estimated that for every acre foot of saturated brine evaporated, 0.20 acre feet of reservoir volume is lost. Because of this situation, saturated brine lakes have limited life spans. For example, a brine lake with a capacity of 1,000 acre feet would be filled with salt after it evaporated only 5,000 acre feet of brine, if the porosity of the salt was 30 percent and there was a negligible amount of clay and other precipitates.

If a saturated brine lake is receiving slimes or mud from potash refining, or if the brine becomes saturated with other minerals, the reservoir capacity is depleted faster. However, if the lake leaks, the life span is extended by the amount of at least 14 percent the volume of leakage.

The direction and amount of leakage from reservoirs is a subject not easily studied, and the results of such studies are often controversial because of the difficulties in obtaining field data relating to the subject. The direction and amount of leakage are related to the permeability of rocks underlying the reservoirs and these permeability values range through a very wide spectrum of values. It is the consensus of hydrologists that all rocks have some permeability, but it is known that these values are so low for certain rocks that for practical purposes these rocks transmit no water.

The permeability of a thick formation of volcanic rock underlying the Los Alamos Scientific Laboratory in northern New Mexico was studied by the U. S. Geological Survey for many years because of the possibility that it may leak radioactive waste water into a lower and valuable aquifer. These studies probably have not provided an accurate estimate on the permeability of this rock, but field tests show that it is virtually impermeable, except at places where it has interconnecting joints or cracks, which permit the movement of water.

There probably is no rock in this area as impermeable as the volcanic tuff at Los Alamos, but there are certain types of sedimentary rocks that are considered to be nearly impermeable. Among these are the mudstones, claystones, and caliche which comprise much of the geologic section. At places the impermeable and permeable rocks are stacked in alternate layers, making it very difficult to assess the picture of reservoir leakage.

The leakage of evaporation ponds can be restricted or eliminated in several ways. If the pond is not large it can be lined with an impermeable plastic lining, but there are difficulties with this treatment. The cost is greater and the technique of sealing adjacent sheets is imperfect (Dallaire 1975, p. 63). Great care must be taken to prevent puncture of the plastic by rocks, and some types of plastic deteriorate from ultraviolet radiation of sunlight. If the pond is to be cleaned periodically or if salt is to be removed, it is possible that the plastic will be punctured by the excavation.

In many cases ponds can be sealed by chemical treatment. If the impounded water or brine has a significant calcium concentration, it is often possible to add sodium carbonate to the water and precipitate calcium carbonate to seal or partly seal the floor of the pond. Sodium carbonate probably is insoluble in most of these brines. For this and other reasons this treatment will be ineffective.

Ponds and irrigation canals are often lined or treated with various clays in attempts to reduce leakage, but for such treatment to be effective the chemical compositon of water must be within discrete ranges (Rolfe and others, 1960), and the effluent brines do not have the proper chemical compositions for maximum effectiveness of this type of treatment. It is believed that the clays in the slimes discharged from the potash refineries are partly effective as a sealant, but they would be more effective if the effluent was of a different composition.

Much thought was given to the problem of sealing the floor of Anderson Lake, before it received brine. Clay, cement and asphalt linings were proposed but these suggestions were abandoned because of their great expense, and the only treatment given to the floor of this reservoir was to plow and compact the lower 52 acres. This treatment, despite some contrary opinions, was only partly effective. Leakage may have been inhibited by about 30 percent during the early stages of brine storage.

4. Residual Impacts

a. Air

The following recommended mitigating measures are directed toward mitigating the impacts of the proposed action upon air: 1, 2, 3, 12, 15, 18, 34, 36, and 47. Even with the implementation of these mitigating measures, the residual impacts on air quality can not be quantified because air emission regulations have not yet been developed for the potash industry. If no regulations were to be developed, the residual impacts would be the same as the conditions described for the existing environment. However, EIA does plan to develop regulations; therefore, the actual residual impacts will be determined by the amount of emission control required by the regulations. Considering this variable, this section on residual impacts presents the impacts which can be expected at three assumed levels of air emission control:

> First, control necessary to meet the 30 day ambient air standard;
>
> Second, control necessary to meet the annual ambient air standard;
>
> Third, control necessary to meet the 24 hour ambient air standard.

In addition, this section presents the impact anticipated from implementation of IMC's proposal to remove their Ozark evaporators. As discussed under Mitigation Measures, reductions in the particulate emissions from several potash refineries would be required in order to comply with New Mexico ambient air quality standards. The New Mexico Environmental Improvement Agency has the enforcement responsibility in this regard. As summarized in Table 4 of the Mitigation Measures section, an overall additional reduction of particulate emissions of 50 percent would be required in order for the refineries to meet the thirty-day average standard, 71 percent to meet the annual standard, and 91 percent to meet the 24-hour maximum standard. The discussion which follows presents an analysis of the residual impacts associated with achieving these three levels of reductions in particulate emissions.

The thirty-day average standard for suspended particulates is 90 ug/m^3, and 4 refineries (Duval, AMAX, PCA, and IMC) would be required to provide additional reductions in particulate emissions in order to be in compliance with the thirty-day standard. The required reductions at the individual refineries are summarized in Table 4 in the Mitigation Measures section. Figures 9 and 10 summarize the isoconcentration lines of suspended particulates in the vicinity of the Duval refinery for the worst month (June) and on the annual basis, respectively. Figures 11 and 12 are comparable print outs for the AMAX refinery, Figures 13 and 14 for the PCA refinery, and Figures 15 and 16 for the IMC refinery. Figure 17 shows the isoconcentration lines of suspended particulates on an annual basis around the 7 refineries, with each refinery controlled to assure compliance with the 30-day standard. It should be noted that although the thirty-day standard can be met with this control strategy, the annual standard will still be exceeded in the vicinity of the Duval, AMAX, PCA, and IMC refineries. In addition, the maximum 24-hour standard will still be exceeded, even with the provision of controls for meeting the thirty-day standard. If the control technology for meeting the thirty-day standard is implemented, site-specific beneficial impacts for the 4 refineries required to provide additional controls will occur. In addition, regional beneficial impacts will also accrue since 4 of 7 refineries will provide an average of 50 percent additional reduction in their particulate emissions.

The overall additional reduction in particulate emissions required to meet the annual geometric mean standard for suspended particulates is 71 percent. Four refineries (Duval, AMAX, PCA, and IMC) would be required to provide additional particulate emission controls in order to be in compliance with the annual standard. The specific percentage reductions are shown in Table 4 in the Mitigation Measures section. Figure 18 shows the isoconcentration lines for the annual geometric mean in the vicinity of the Duval refinery. Figures 19-21 show similar information for AMAX refinery, PCA refinery, and IMC refinery, respectively. Table 16 summarizes the maximum annual ground level concentrations resulting from the implementation of these additional controls. Figure 22 shows the composite analysis for all 7 refineries following the addition of the controls required for compliance with annual standards. The implementation of these controls would provide beneficial impacts in the site-specific sense for the Duval, AMAX, PCA, and IMC refineries; and it would provide a beneficial impact in the region since the overall ambient air concentrations of suspended particulate matter would be reduced. It should be noted that compliance with the annual standard would also accomplish compliance with the thirty-day standard, however, the

Fig. 9 June Isoconcentration Lines of Suspended Particulates in the Vicinity of Duval with Required Reduction for 30-Day Standard

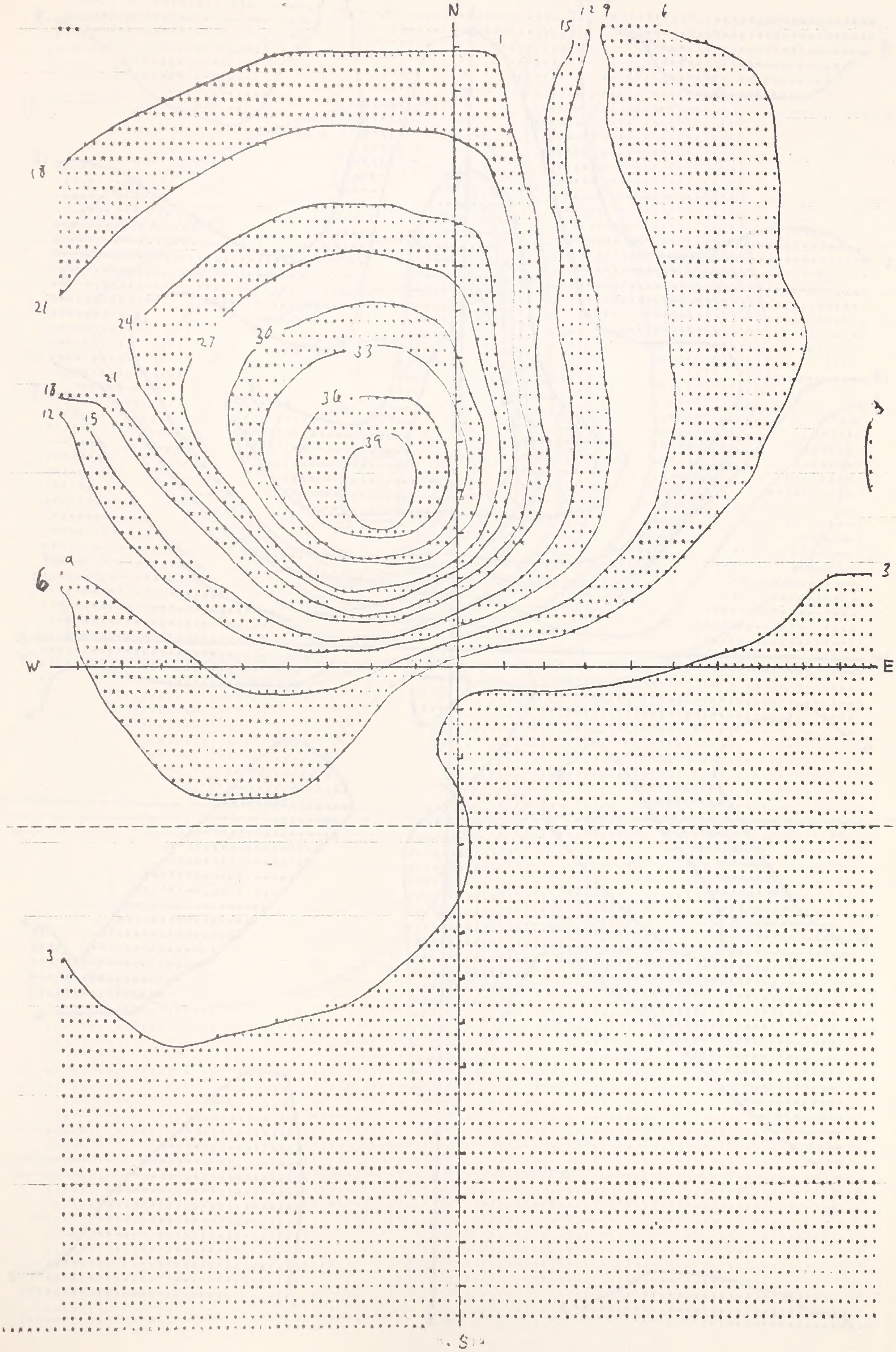


Fig. 10 Annual Isoconcentration Lines of Suspended Particulates in the Vicinity of Duval with Required Reduction for 30-Day Standard

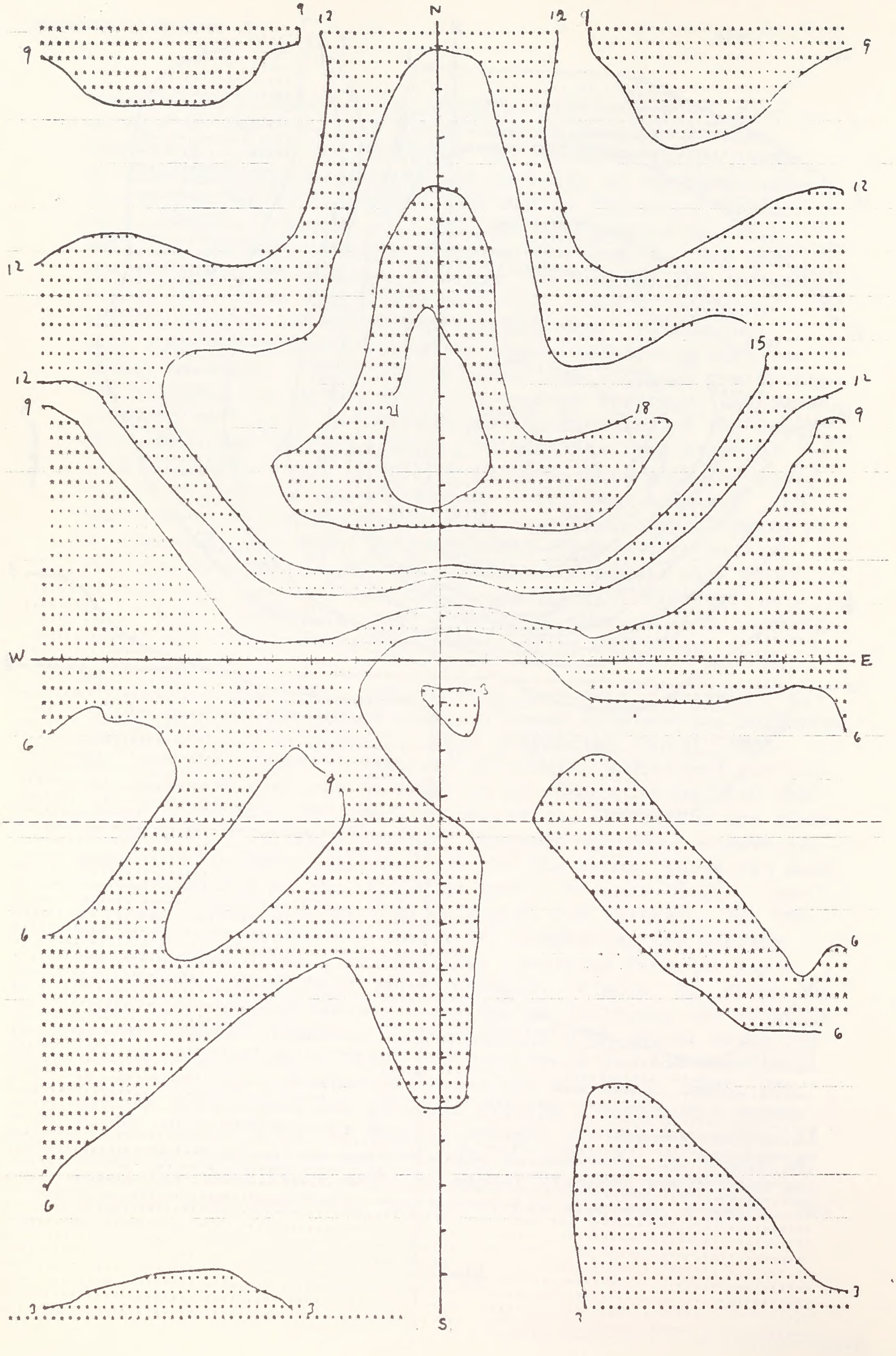


Fig. 11 June Isoconcentration Lines of Suspended Particulates in the Vicinity of AMAX with Required Reductions for 30-Day Standard

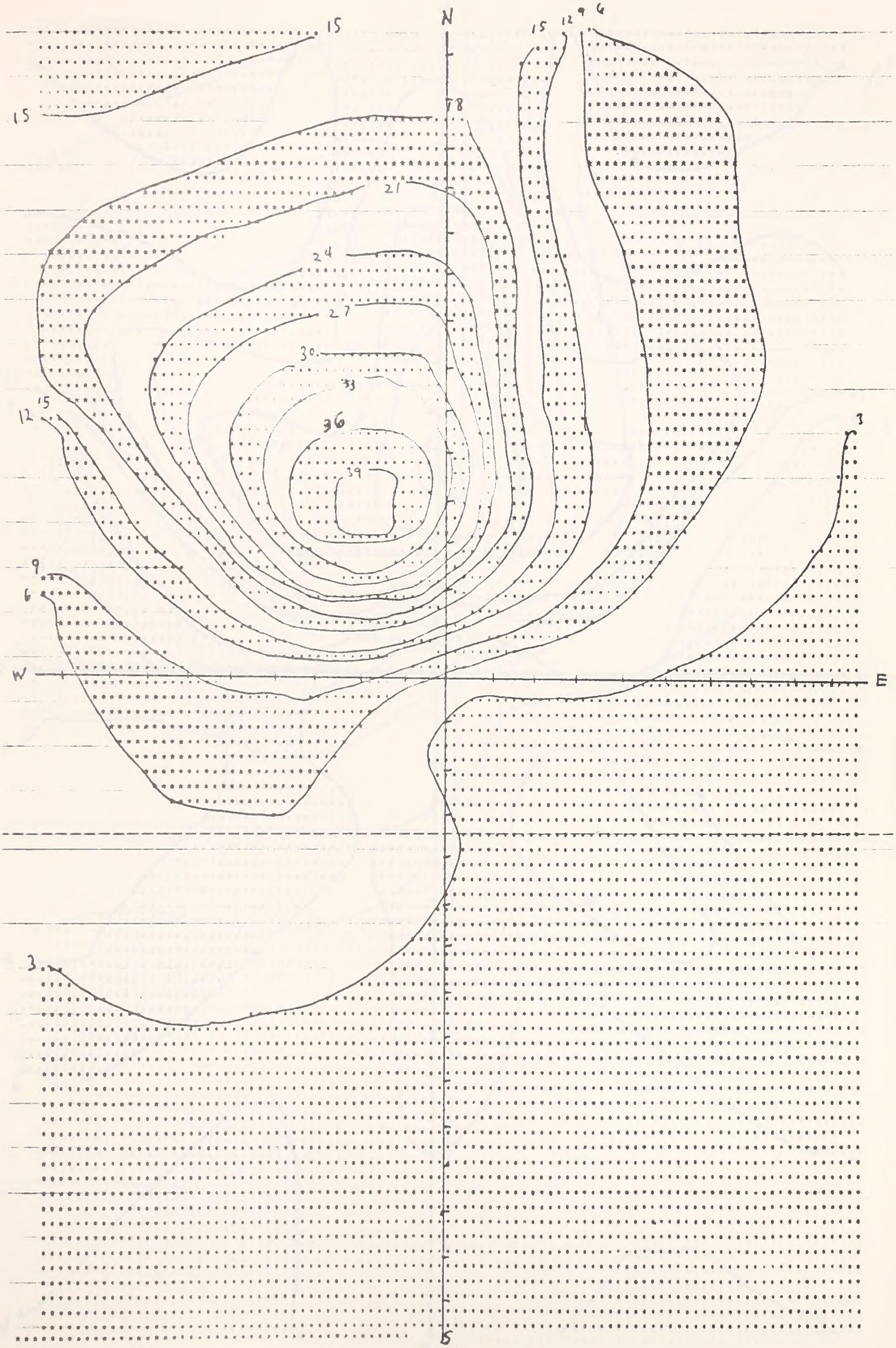


Fig. 12 Annual Isoconcentration Lines of Suspended Particulates in the Vicinity of AMAX with Required Reductions for 30-Day Standard

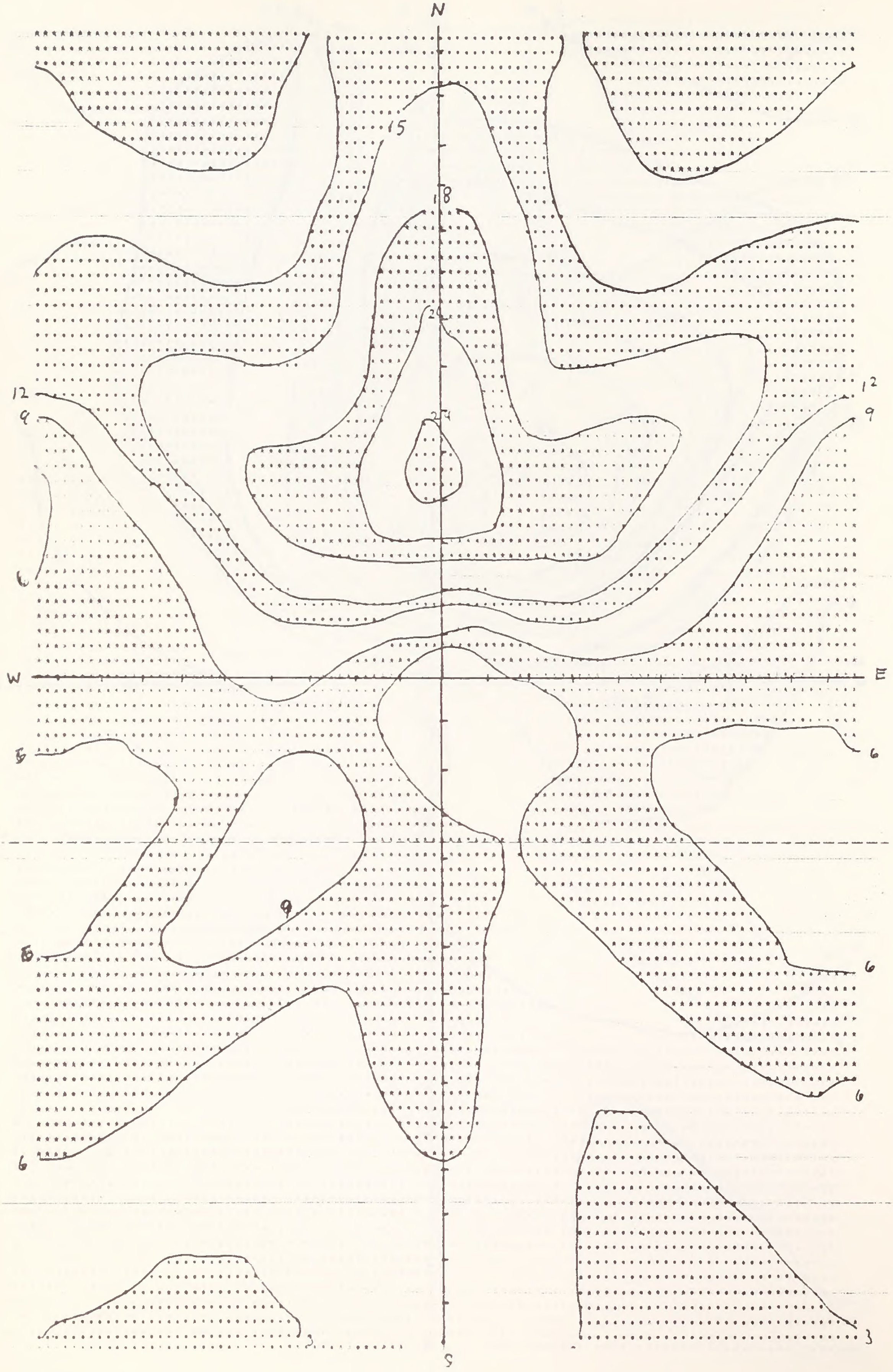


Fig. 13 June Isoconcentration Lines of Suspended Particulates in the Vicinity of PCA with Required Reduction for 30-Day Standard

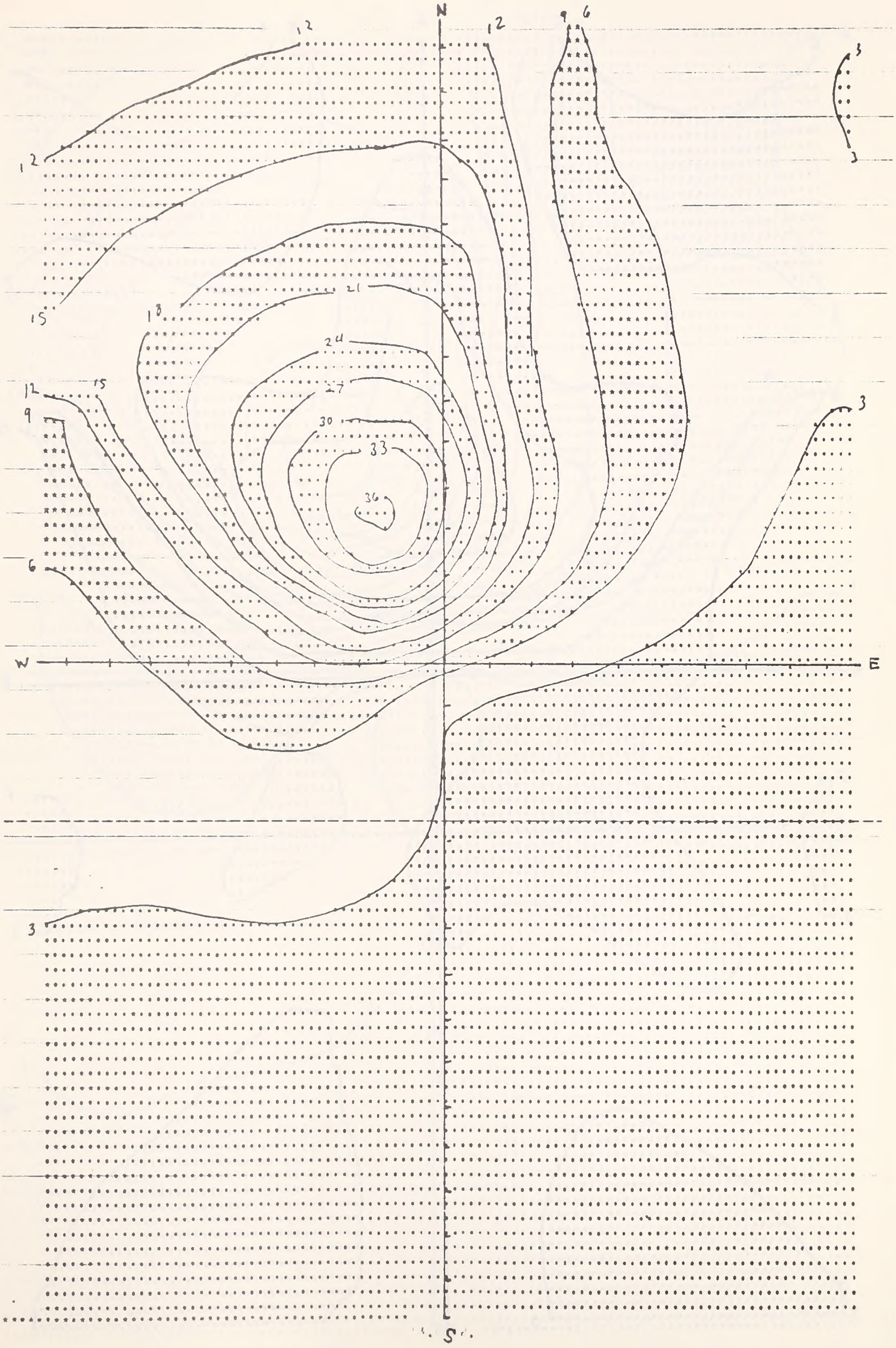


Fig. 14 Annual Isoconcentration Lines of Suspended Particulates in the Vicinity of PCA with Required Reduction for 30-Day Standard

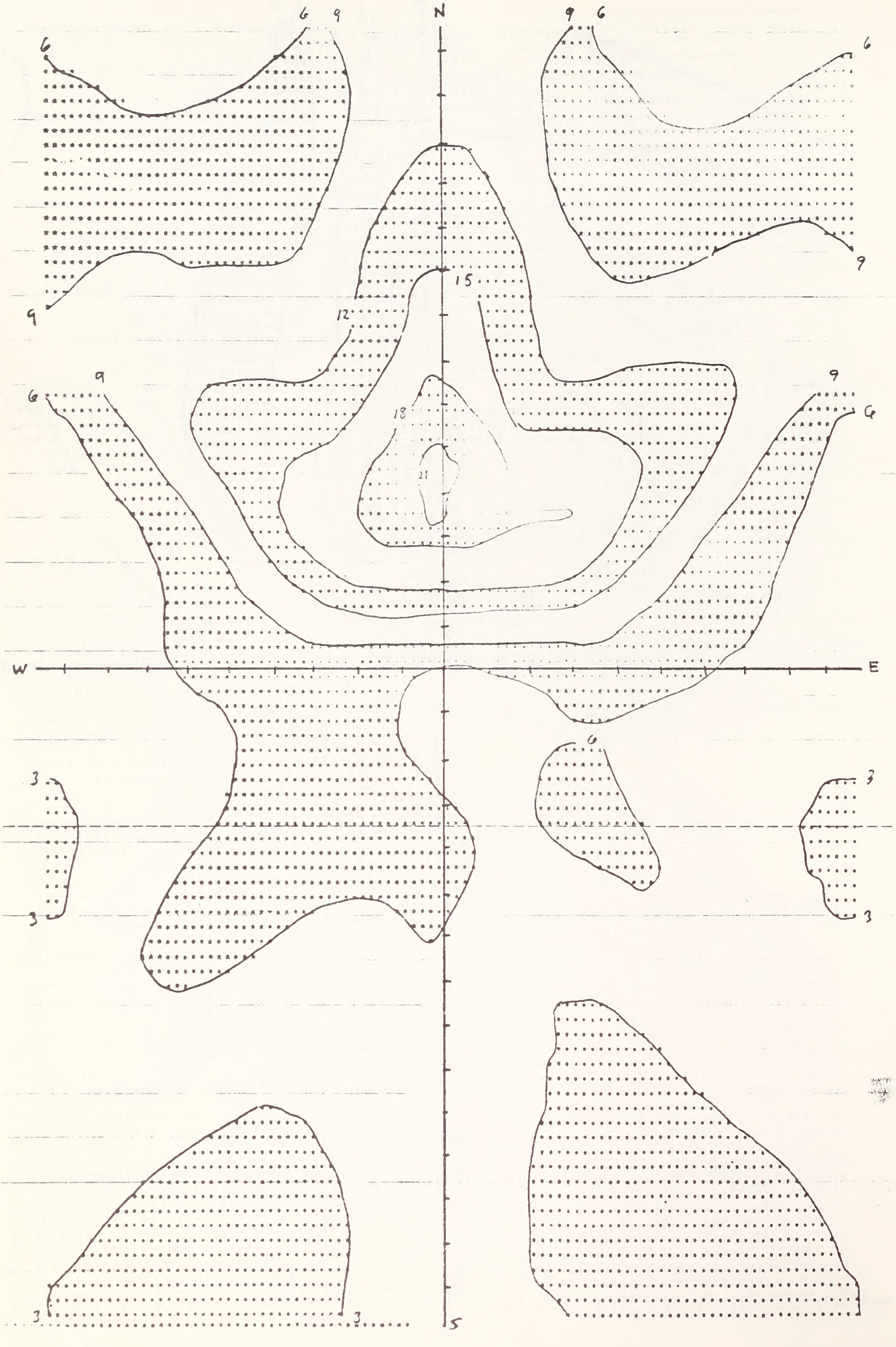


Fig. 15 June Isoconcentration Lines of Suspended Particulates in the Vicinity of IMC with Required Reduction for 30-Day Standard

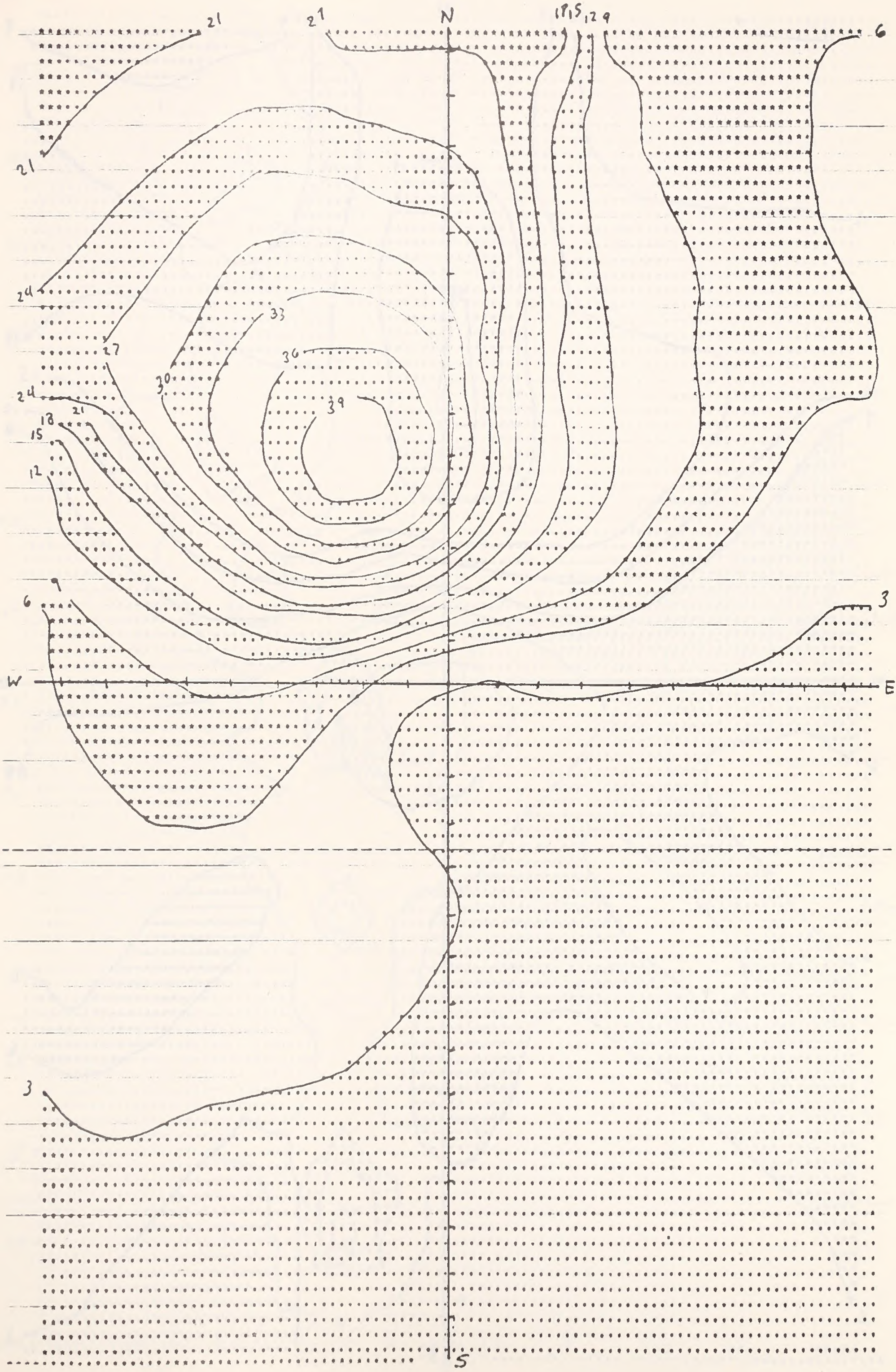


Fig. 16 Annual Isoconcentration Lines of Suspended Particulates in the Vicinity of IMC with Required Reduction for 30-Day Standard

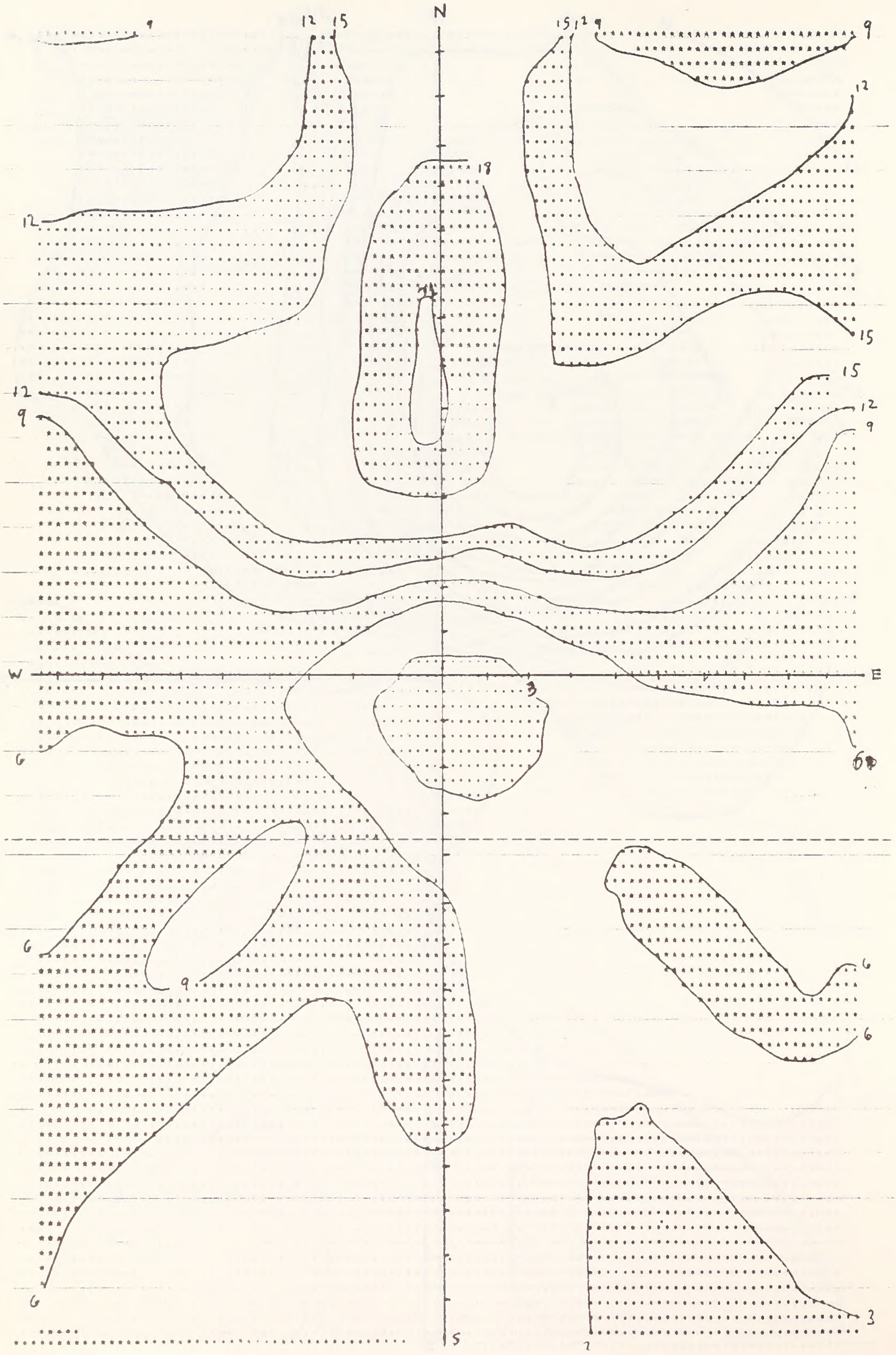


Fig. 17 Annual Isoconcentration Lines of Suspended Particulates in the Vicinity of Seven Potash Refineries with Control to Comply with 30-Day Standard

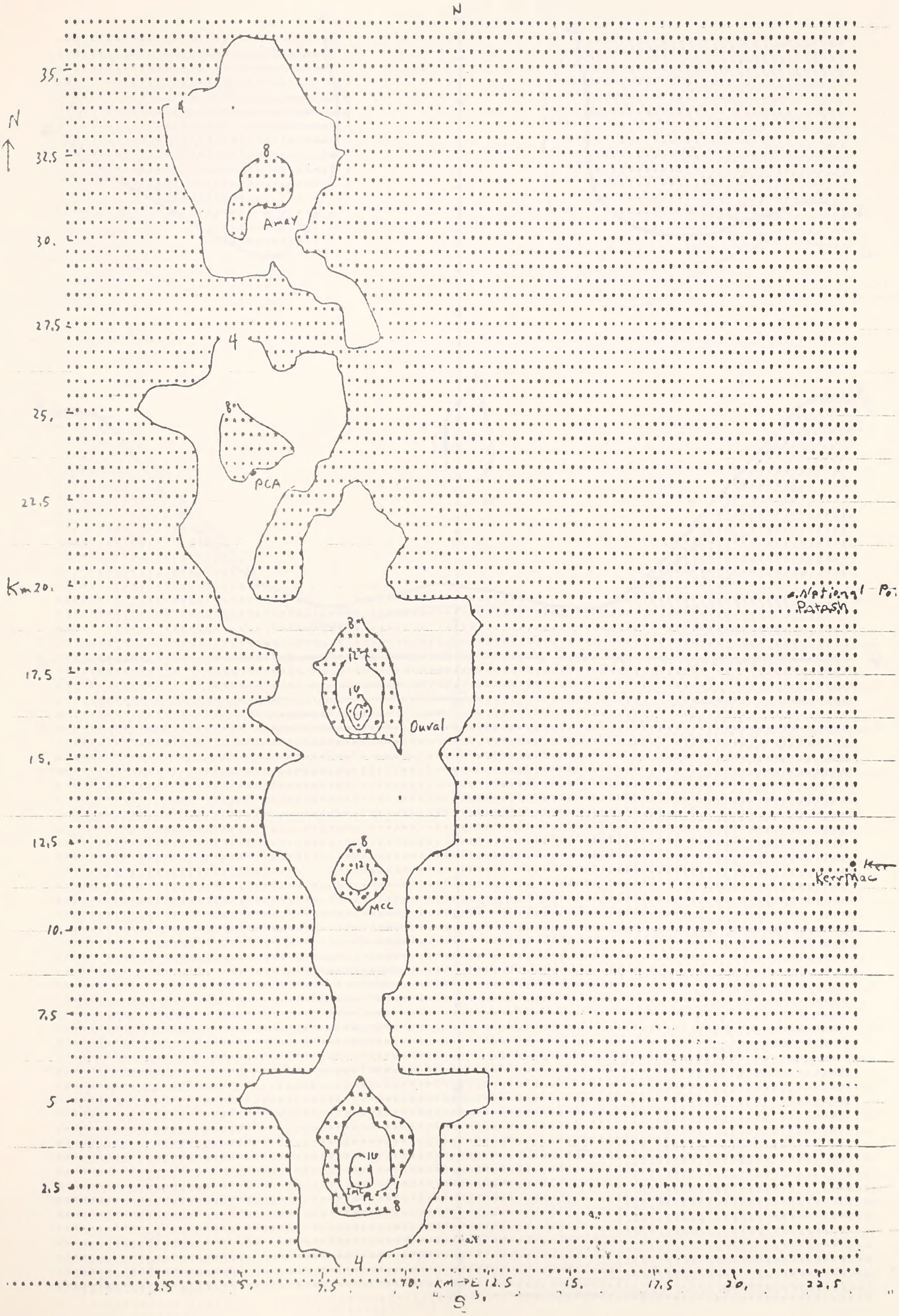


Fig. 18 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of Duval with Additional Controls to Meet Annual Geometric Mean Standard

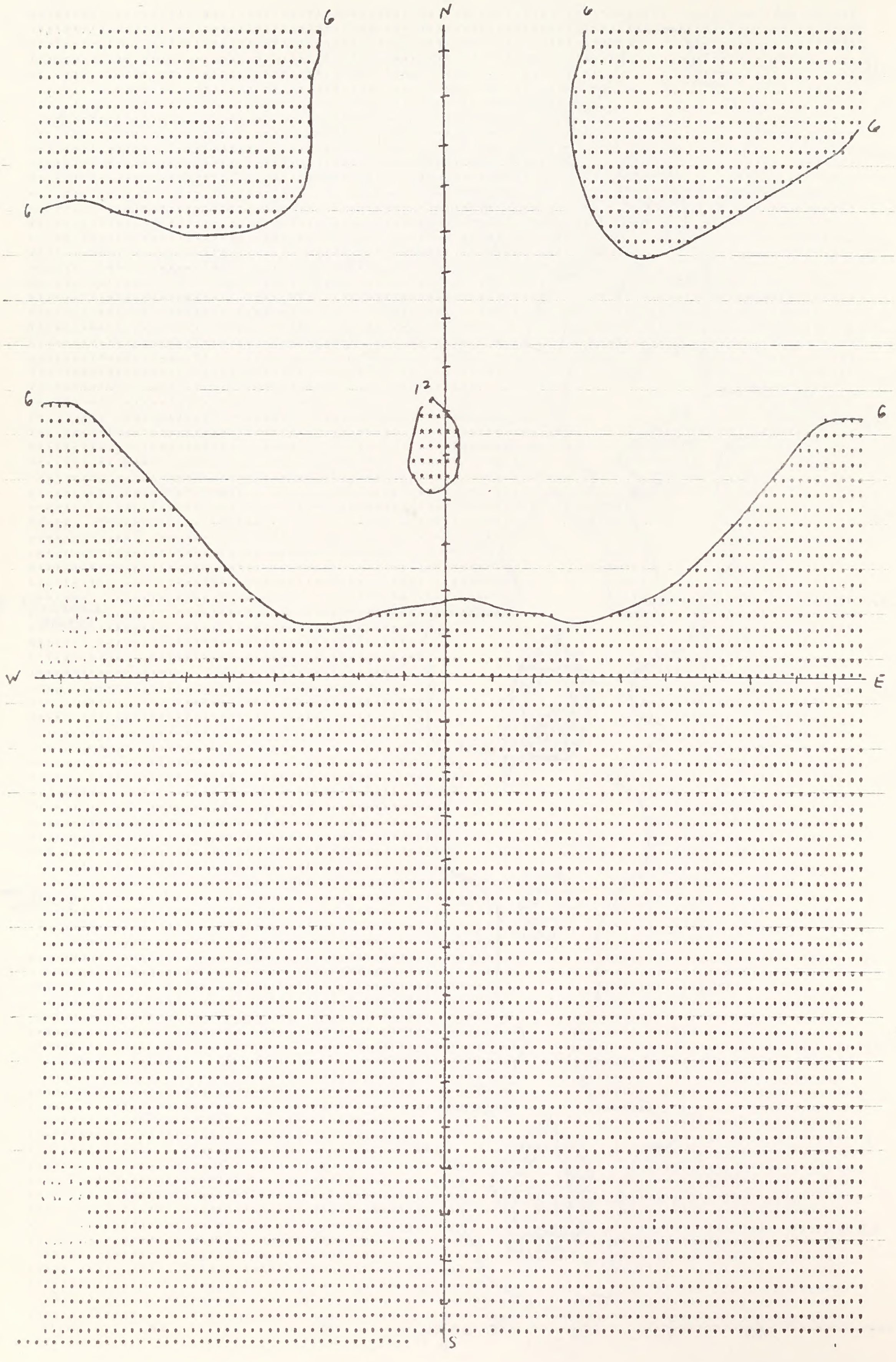


Fig. 19 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of AMAX with Additional Controls to Meet Annual Geometric Mean Standard

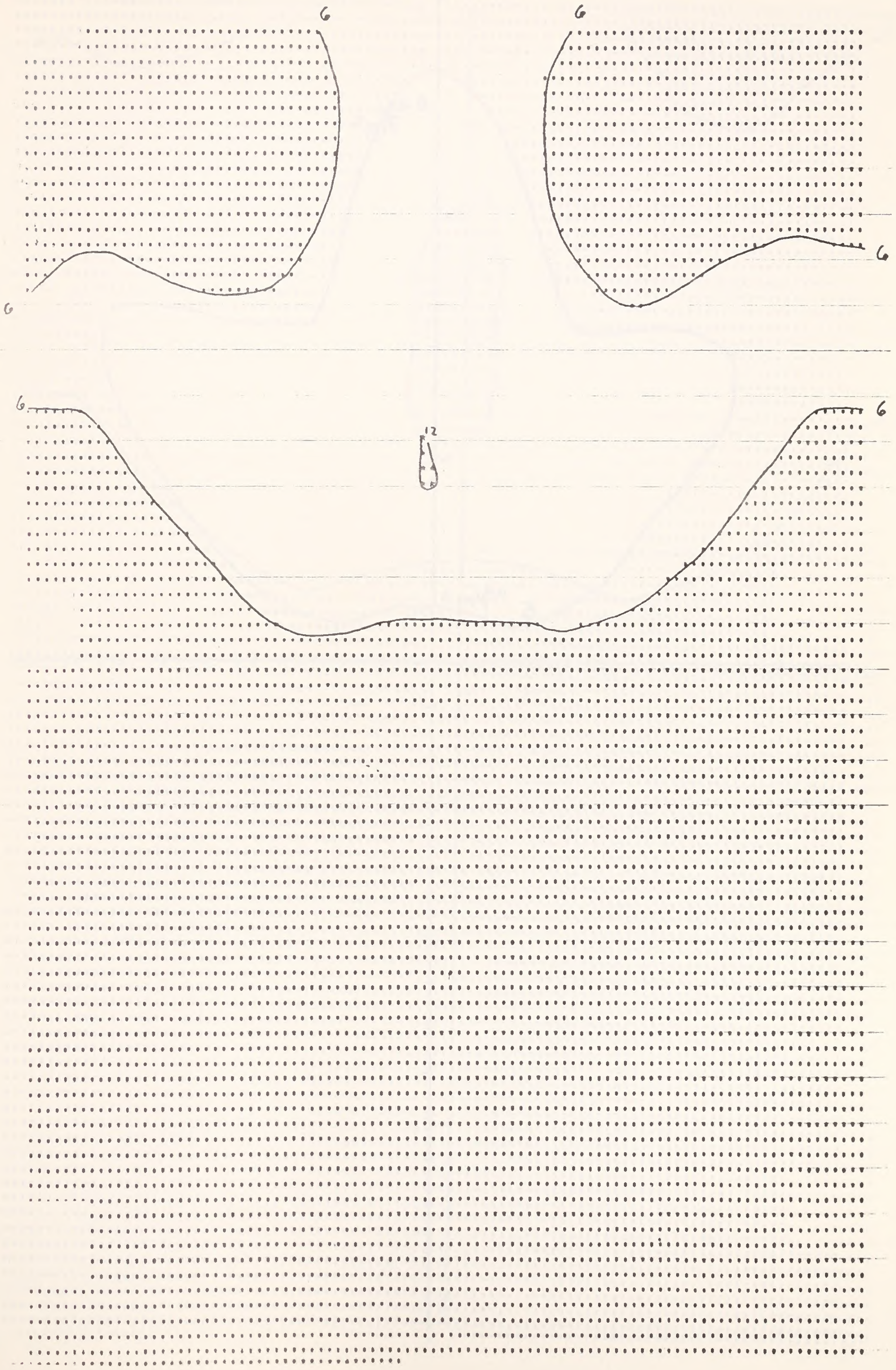


Fig. 20 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of PCA with Additional Controls to Meet Annual Geometric Mean Standard

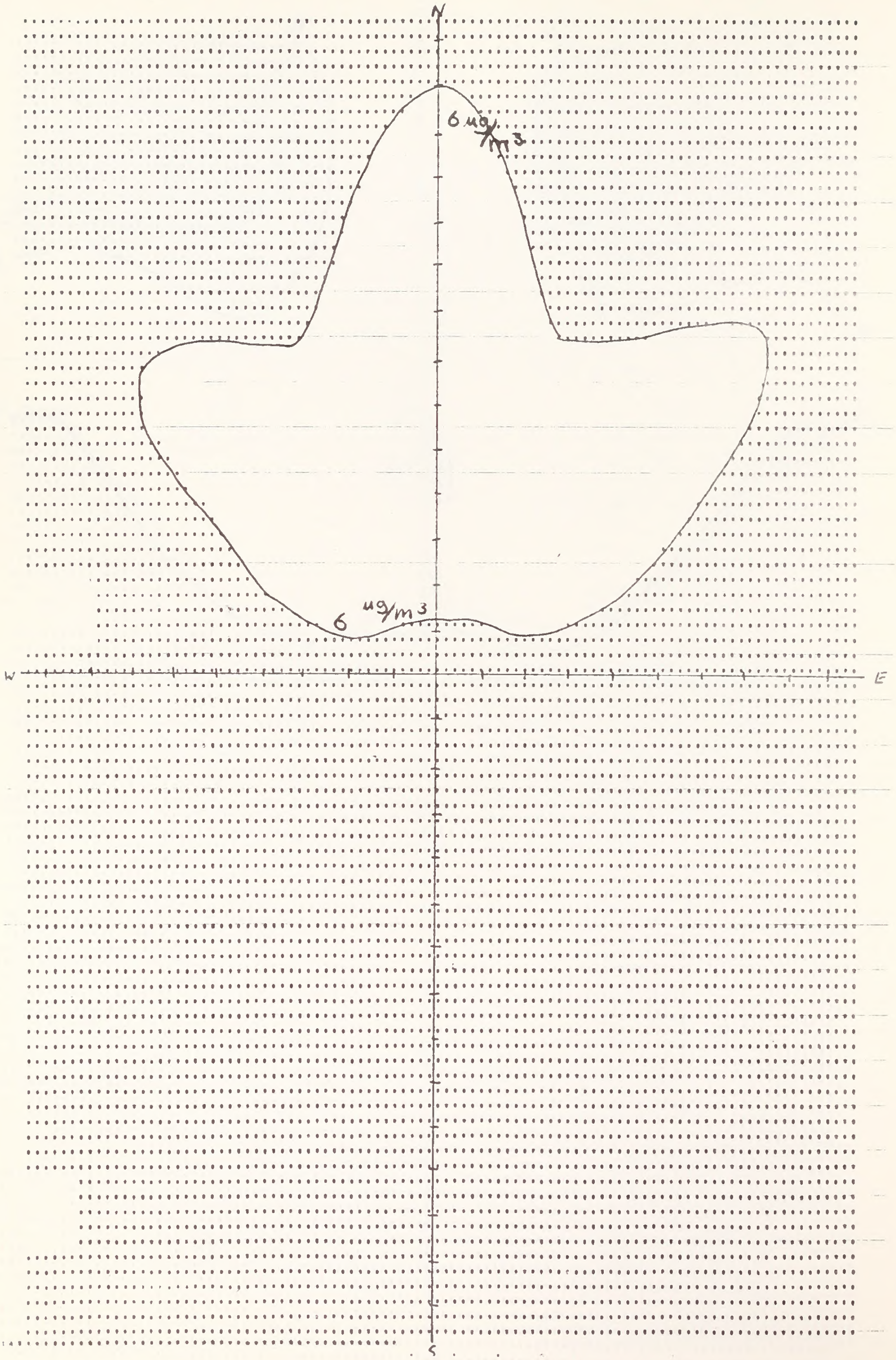


Fig. 21 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of IMC with Additional Controls to Meet Annual Geometric Mean Standards

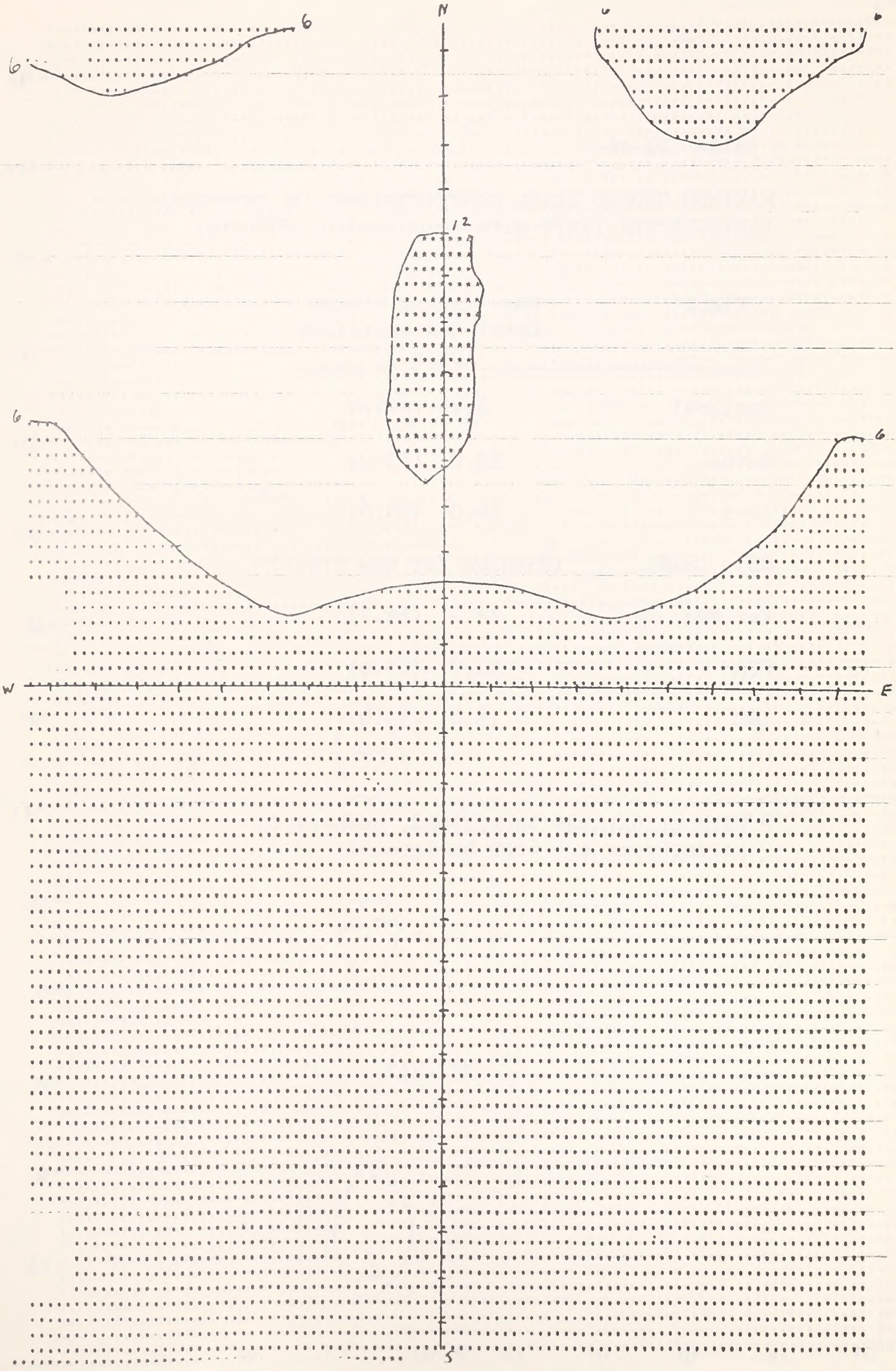


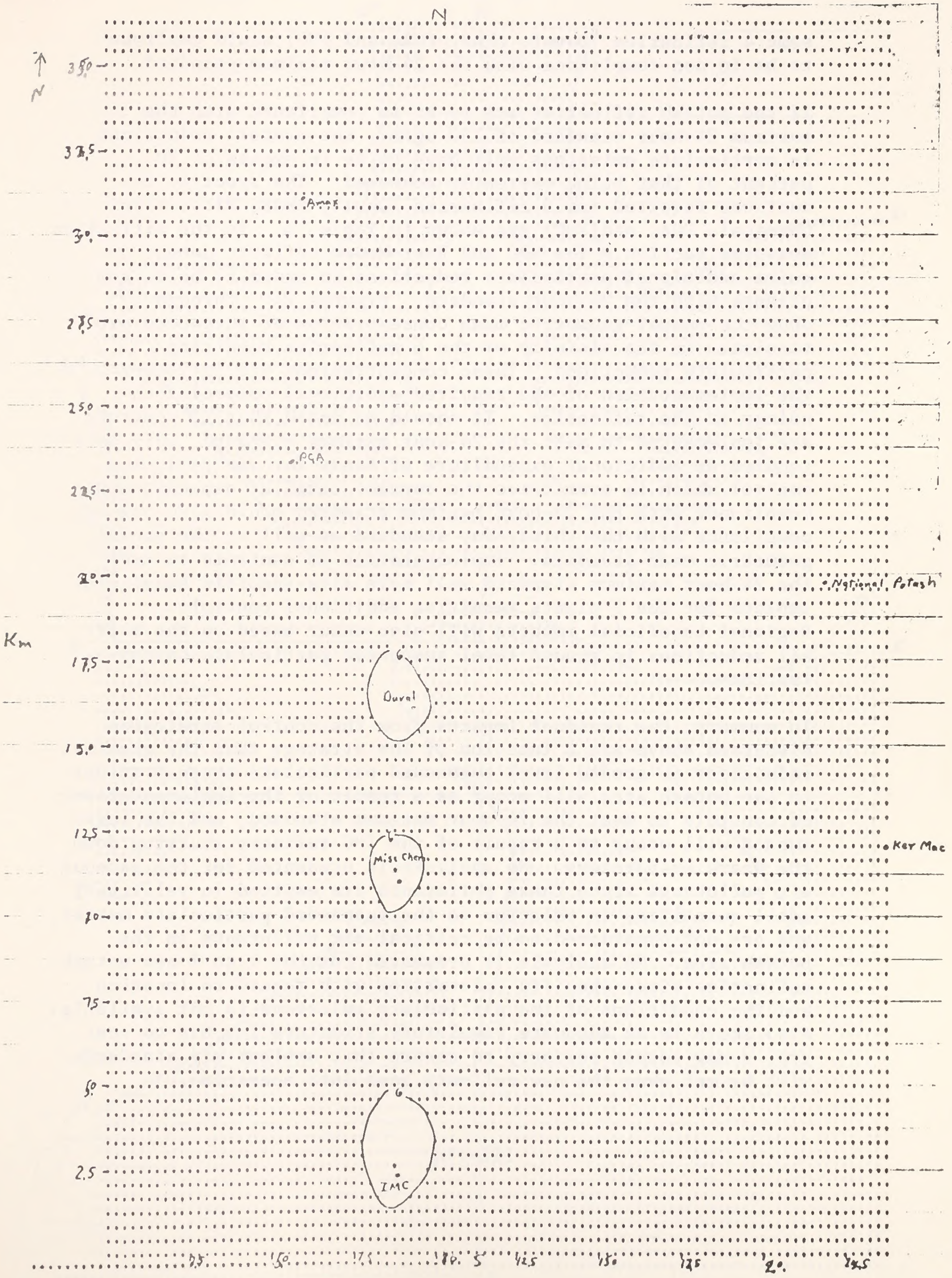
Table III-16

MAXIMUM GROUND LEVEL CONCENTRATIONS OF SUSPENDED PARTICULATES (1978 with recommended controls)

Plant	Max. Annual Ground Level Concentration ($\mu g/m^3$)
National	2.7* (42.7)
Duval	15.0 (55.0)
Amax	15.0 (55.0)
Miss Chem	(Unknown for New Plant)
Ker Mac	14.7 (54.7)
PCA	15.0 (55.0)
IMC	15.0 (55.0)

* Without natural background, numbers in parentheses are with background.

Fig. 22 Composite Analysis for all Seven Refineries Following Addition of Controls Required to Comply with Annual Standard



same 4 refineries (Duval, AMAX, PCA, and IMC) would continue to be in non-compliance with the 24-hour maximum standard.

If the potash refineries are to be in compliance with the maximum 24-hour standard of 150 ug/m^3, the overall reductions in particulate emissions will have to be in excess of 90 percent of that being currently achieved. The specific reductions required for 5 refineries (Duval, AMAX, Mississippi Chemical, PCA, and IMC) are shown in Table 4 in the Mitigation Measures section. The NPC and Kerr-McGee refinery do not require additional particulate reductions in order to be in compliance with the 24-hour standard. Figures 23 through 27 show the annual geometric mean concentration of suspended particulates in the vicinity of the 5 refineries requiring particulate reductions. These concentrations are following the implementation of the required additional control technology at the refineries. It should be noted that if controls are implemented to meet the 24-hour maximum standard, this will require an additional expenditure of funds for air pollution control which is over twice the current level of expenditures. Compliance with the 24-hour maximum standard would also provide compliance with the thirty-day standard as well as the annual geometric mean standard. Implementation of controls to meet the 24-hour maximum standard will have site-specific beneficial impacts for the 5 plants requiring additional controls. Regional beneficial impacts will also occur based on the overall reductions in ground level suspended particulate concentrations.

In summary, the residual impacts from the control strategies discussed above are a function of the strategy that the greatest reductions in ground level suspended particulate concentrations in the potash area will occur as a result of the implementation of controls to meet the 24-hour maximum standard, and the least impact will occur as a result of the IMC refinery shutting down the Ozark evaporators. No analysis is presented for the gaseous air pollutants since these pollutants are emitted in relatively small quantities in relation to the suspended particulate matter, and are not considered to be critical air pollutants in the potash area. No analysis is presented for the 1 to 7 new potash refineries since specific information with regard to location and the conditions of the particulate emissions is not available. Also there is an adequate regulatory structure for EIA to control a new potash refinery to ensure that ambient air standards will be met when the new refinery goes into operation.

Fig. 23 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of Duval with Required Reductions for 24-Hour Standard

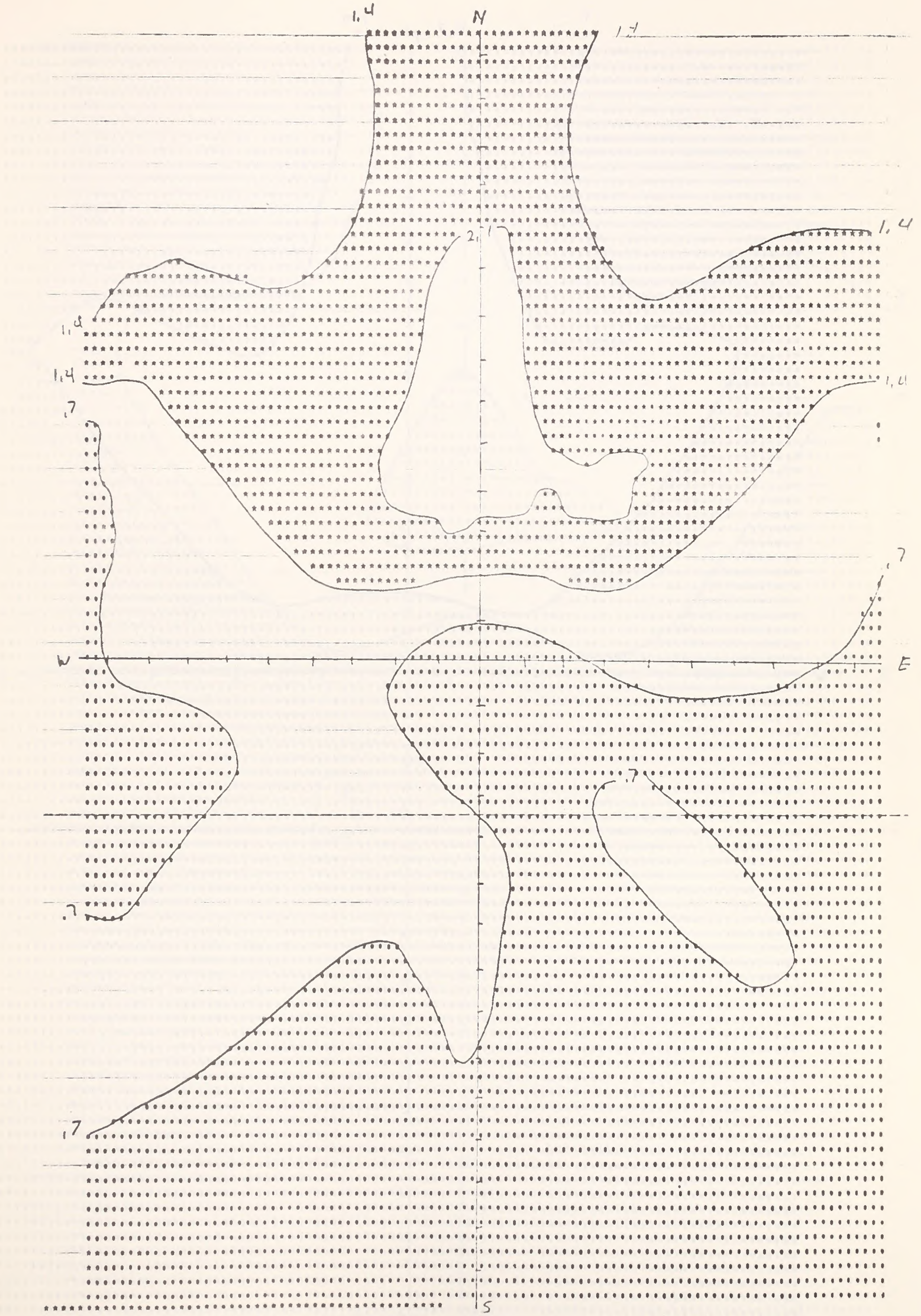


Fig. 24 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of AMAX with Required Reductions for 24-Hour Standard

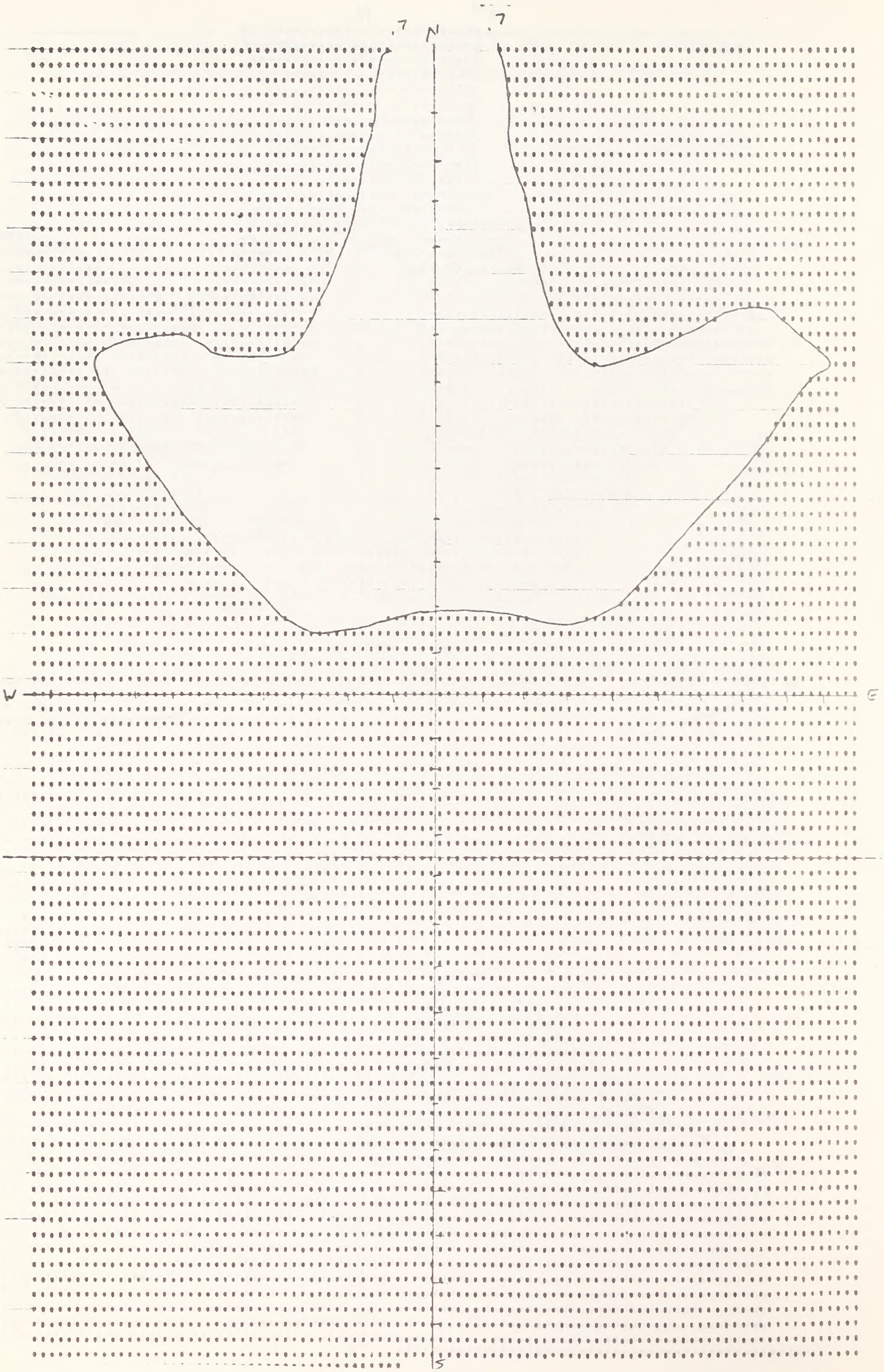


Fig. 25 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of MCC with Required Reductions for 24-Hour Standard

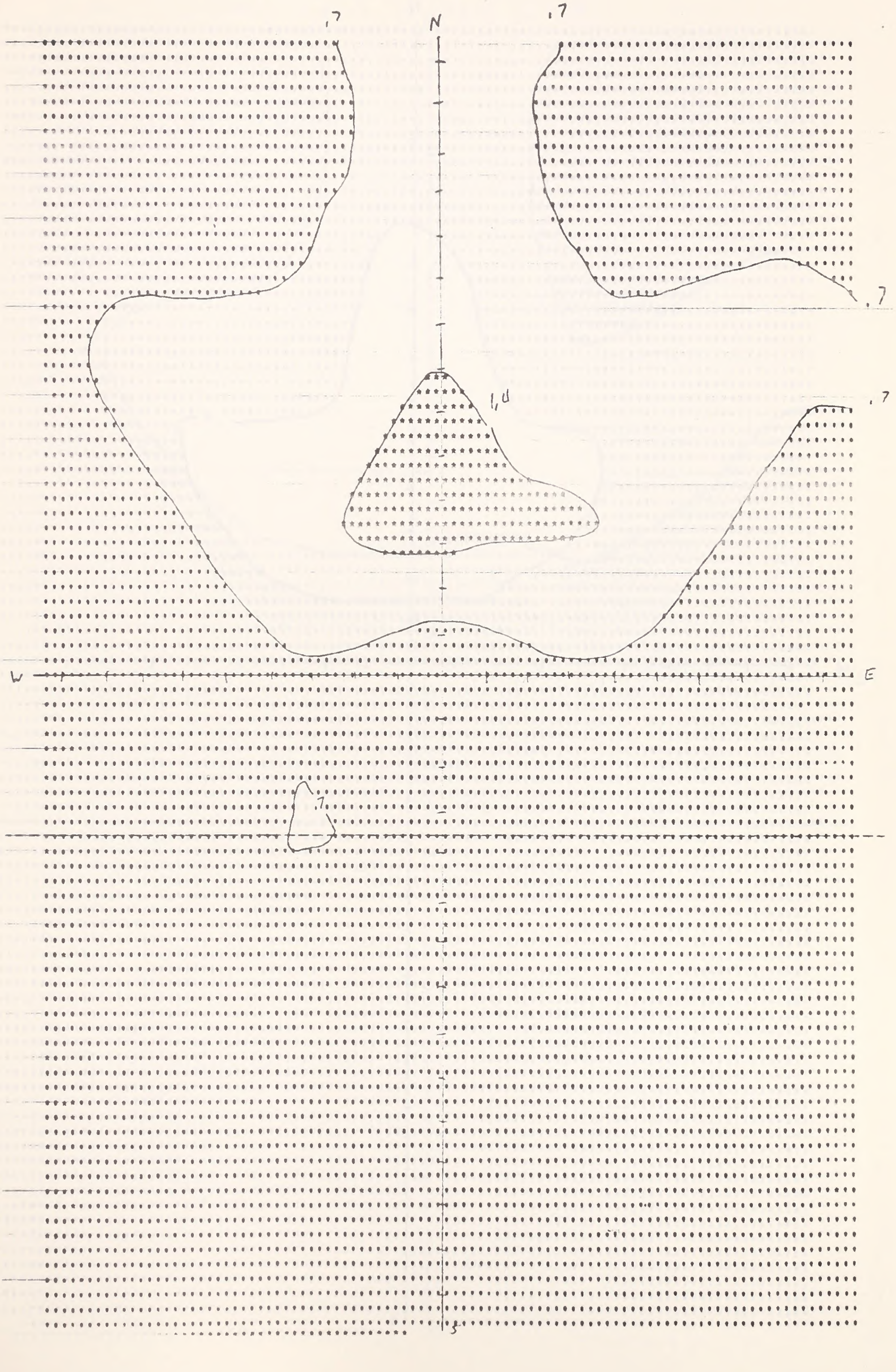


Fig. 26 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of PCA with Required Reductions for 24-Hour Standard

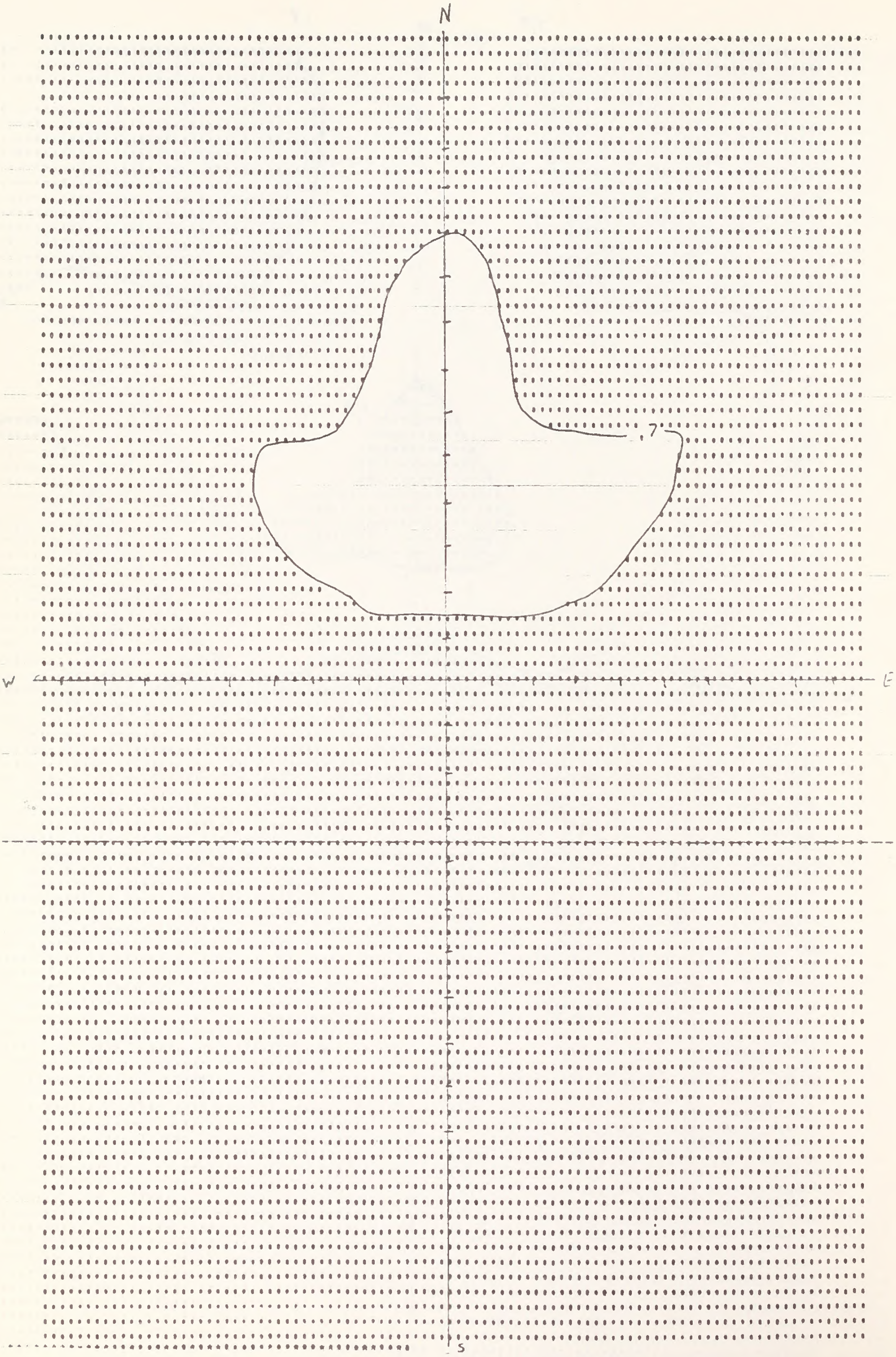
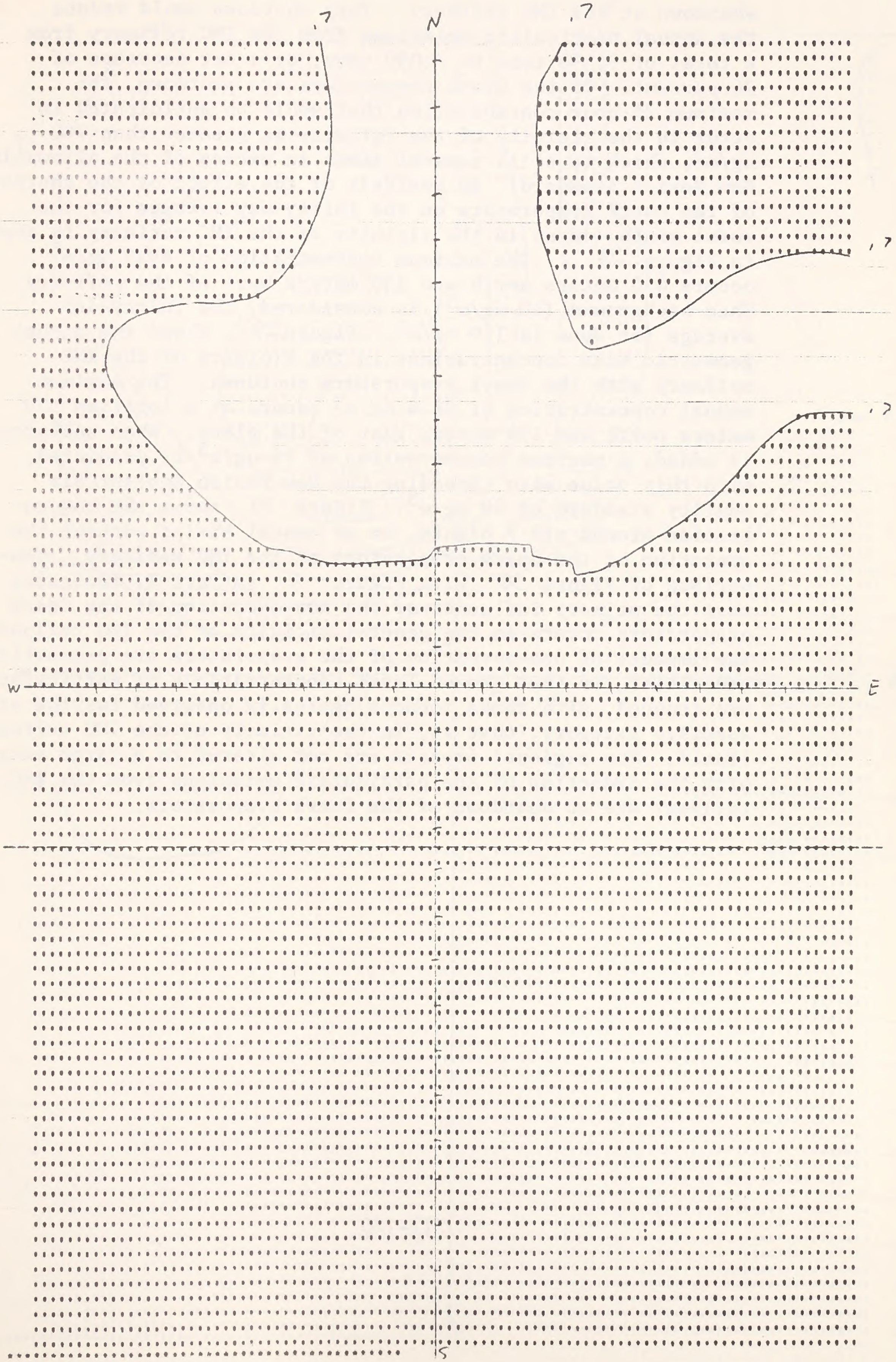


Fig. 27 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of IMC with Required Reductions for 24-Hour Standard



One of the proposed actions is that the Ozark evaporators be shutdown at the IMC refinery. This shutdown would reduce the annual particulate emissions from the IMC refinery from a total of 9,498 tons to 7,050 tons, or a net decrease of 26 percent. If the Ozark evaporators are shutdown, the maximum 24-hour concentration that would be anticipated to occur in the vicinity of the refinery is greater than 740 ug/m^3, which is still several times in excess of the allowable New Mexico standard. An analysis of the effect of the shutdown of the Ozark evaporators on the thirty-day average for the worst month (June) in the vicinity of the IMC refinery is shown in Figure 28 . The maximum concentration of 69.5 ug/m^3 occurs 450 meters north and 250 meters west of the refinery. When background (40 ug/m^3) is considered, the thirty-day average for June is 110 ug/m^3. Figure 29 shows the annual geometric mean concentrations in the vicinity of the IMC refinery with the Ozark evaporators shutdown. The maximum annual concentration of 38.8 ug/m^3 occurs at a location 550 meters north and 150 meters east of the plant. When background is added, a maximum concentration of 79 ug/m^3 is predicted, with this value also exceeding the New Mexico ambient air quality standard of 60 ug/m^3. Figure 30 shows the concentration around all 7 plants, on an annual basis, without the operation of the Ozark evaporators at the IMC refinery. Comparison of Figure 30 with Figure 9 in Part II indicates that the primary influence of the non-operation of the Ozark evaporators occurs in the general vicinity of the IMC refinery. The impacts of non-operation of the evaporators are primarily beneficial, in that ground level concentrations of particulates are reduced, with these impacts basically observed for the site-specific category, that is, in the vicinity of the IMC refinery itself. The regional impacts are not altered to a large extent with the reduction of the particulate emissions from the IMC refinery due to shutdown of the Ozark evaporators.

Fig. 28 June Isoconcentration Lines of Suspended Particulates in Vicinity of IMC After Removal of Ozark Evaporators

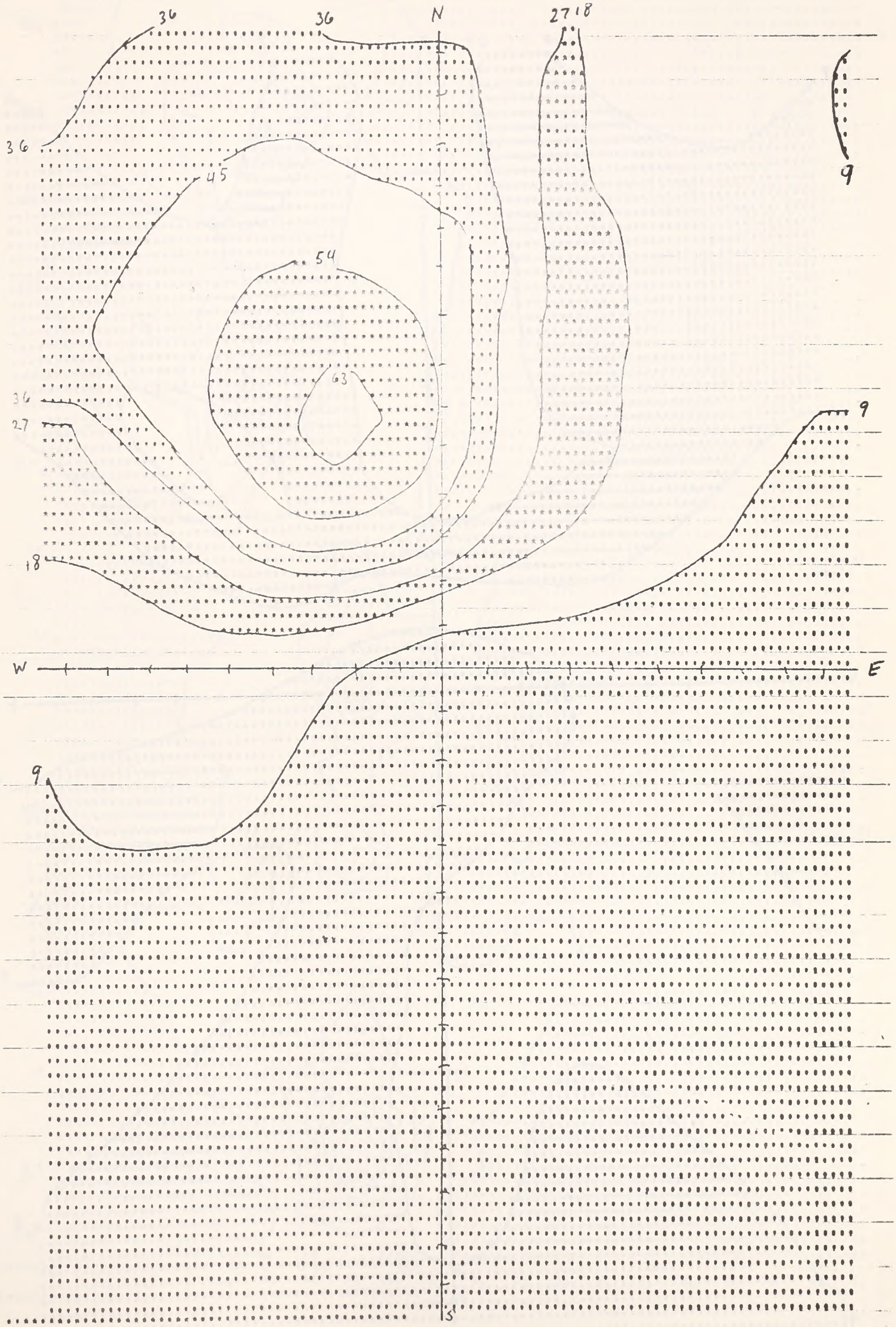


Fig. 29 Annual Isoconcentration Lines of Suspended Particulates in Vicinity of IMC After Removal of Ozark Evaporators

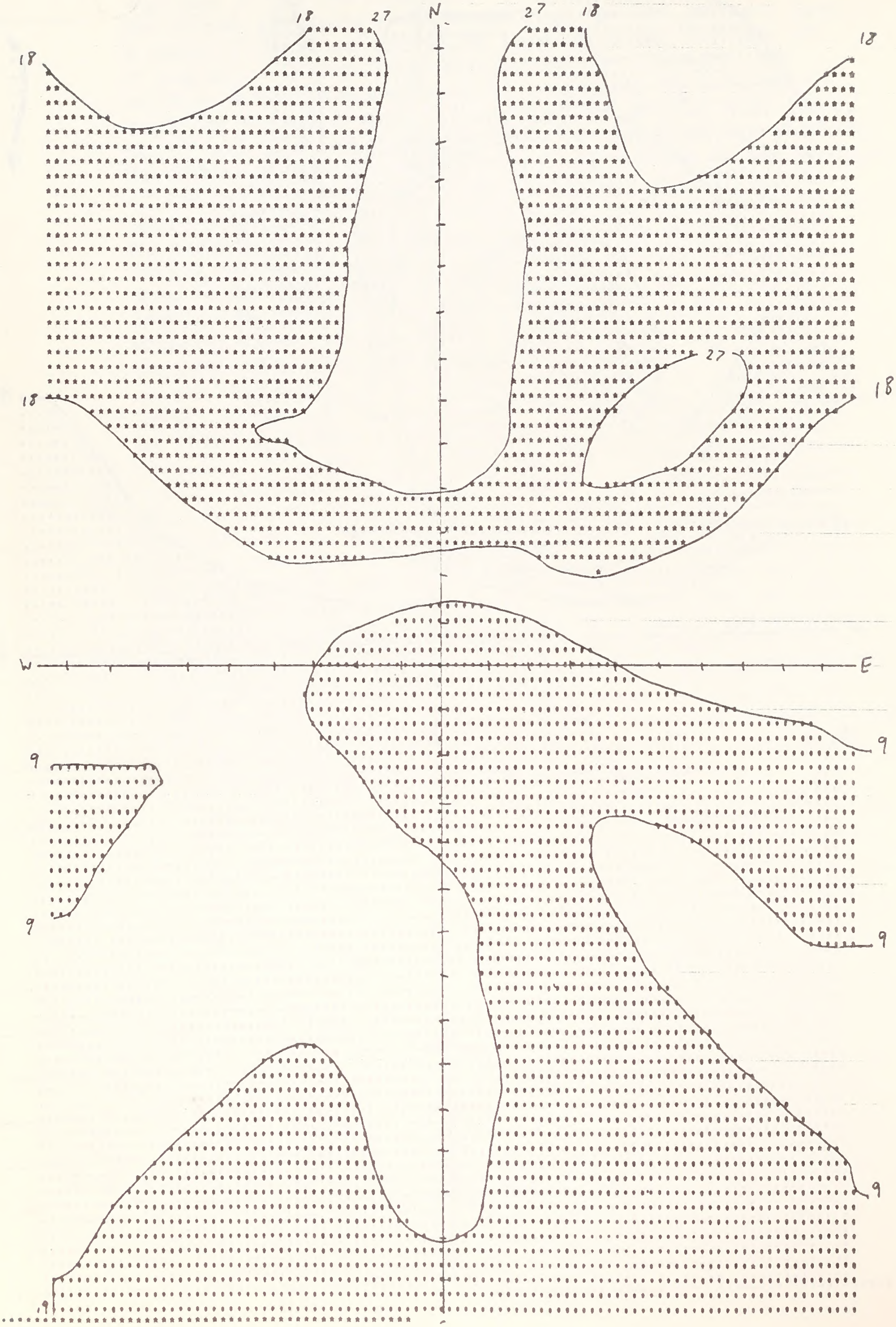
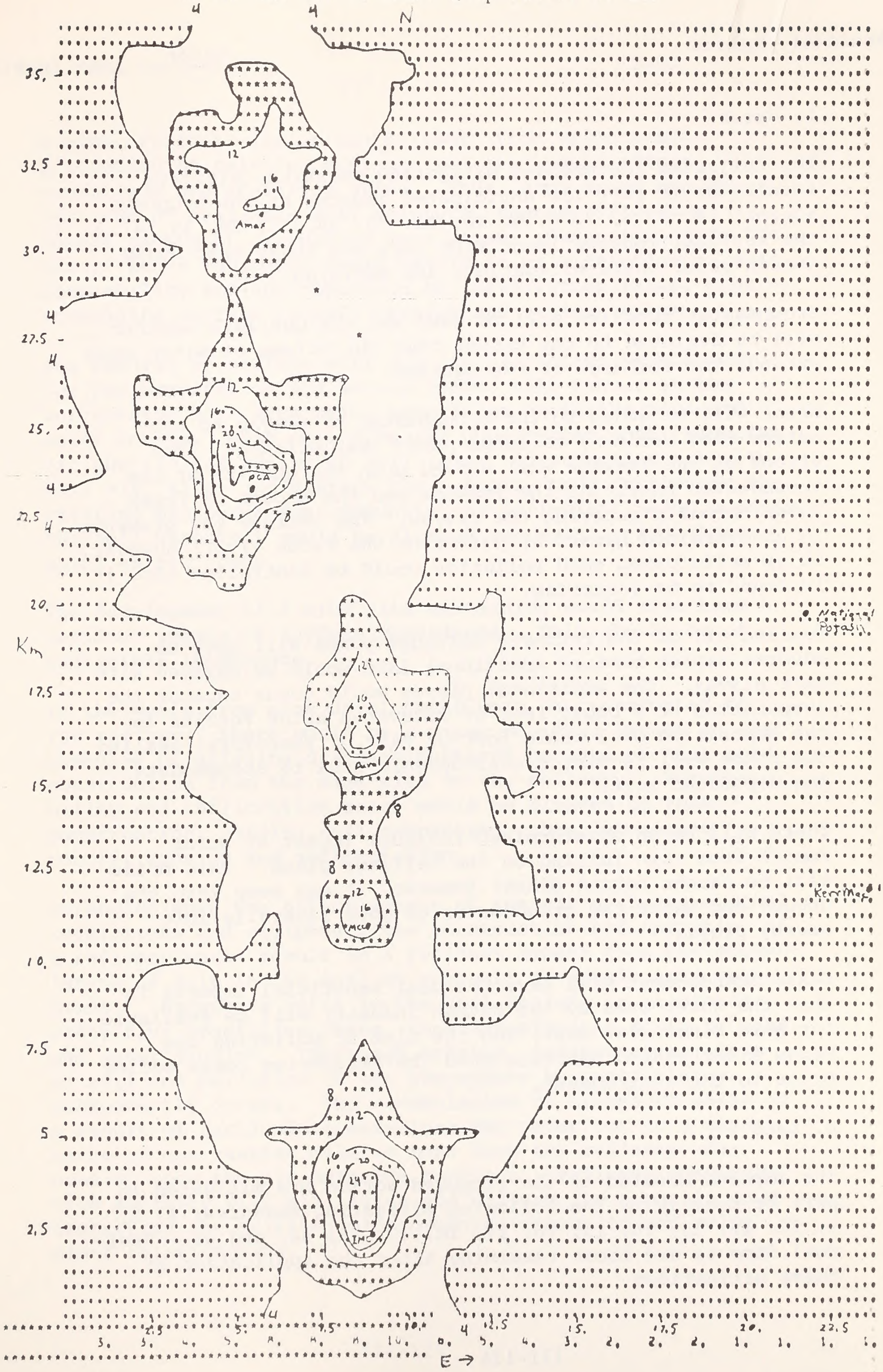


Fig. 30 Composite Analysis of All Seven Refineries After Removal of Ozark Evaporators at IMC



b. Water

The following recommended mitigating measures, mitigate totally or in part the anticipated impacts of the proposed action: (4, 5, 6, 7, 8, 9, 10, 11, 33, 34, 37, 38, 39, 47.) The residual impacts identified here are those that would remain after these mitigations are employed.

Groundwater supplies will be used and the Ogallala aquifer will be depleted to the extent that the volume of water used exceeds the recharge of the aquifer.

Brine will be added to the groundwater or playas to the extent that refinery tailings ponds leak effluent. The effect of the leakage will depend upon the quality of the groundwater receiving the leakage and the amount of fresh water normally entering the playas. The leakage may present an undetermined hazard of polluting the Pecos River; however, it is anticipated such pollution could be controlled once it is found to be occurring.

Sealing all of the refinery tailings ponds will have an adverse impact because additional land would be covered with salt playas. The additional playas would occur because the evaporation of 5 cubic feet of saturated brine results in the deposition of 1 cubic foot of salt. Therefore, sealing the ponds will require a considerable area to accommodate the deposited salt.

There will be an undetermined residual impact of brine runoff from rain falling on the tailings piles. This brine will be caught behind dikes; however, it may seep into the ground and enter the groundwater or move laterally into nearby playas.

Lease abandonment will have residual beneficial impacts in that the water used by the potash industry will be available for more beneficial uses, and the risk of polluting the Pecos River should decrease when the refineries cease adding brine to the environment.

c. Land

The impacts created by the proposed action are mitigated in part or totally by the following mitigating measures: 1, 3, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 33, 34, and 45. Residual impacts are those remaining after the application of these mitigations.

A minor residual impact would result from exploration. Alteration of existing drainage patterns would affect downstream and adjoining areas. Thus, some areas may be deprived of available soil moisture, thereby affecting normal growth of protective vegetation. Compaction from the use of heavy equipment would result in an alteration of soil permeability and the reduction of infiltration rates, thus increasing surface runoff, erosion and sedimentation.

The removal of surface soil and its protective vegetation for pad preparation and access roads, will result in the unprotected soil area being exposed to excessive wind and water forces. Wind will blow the unprotected soil, reducing air quality and adding to soil loss. Construction activity will mix, alter and disturb the topsoil, thus destroying the existing microorganism community and soil-plant relationships. The soil structure would be altered appreciably from that which exists today.

The development of a mine site and mining would also have a residual impact of surface subsidance. This should be of negligible importance.

If the waste from mine development work is transported to the refinery, there would be a minor residual impact in the changing of existing drainage patterns because of haul road construction from the mine site to the refinery. Permeability and inflitration rates would be altered by road construction, causing soil compaction, thus increasing runoff, erosion and sedimentation.

Depending upon the effectiveness of the air emission control regulations and equipment, the construction and operation of a refinery would result in a residual impact from the accumulation of salt in the soil as a result of particulate emissions. Excessive salts in the soil deplete or eliminate protective vegetative cover, thus exposing the soils to wind and water erosion. Increased erosion, sedimentation, loss of soil and pollution of the atmosphere by particulates subsequently occurs. The accumulation of excessive salts as a result of particulate emissions may occur out to a distance of one quarter mile or more from the refinery, depending upon the air emission controls. Refinery construction activity will mix, alter and disturb the topsoil, thus destroying the existing microorganism community and soil-plant relationships.

The refining operation will remove from vegetative production an estimated 580 acres of soil surface at each site. This includes the soil areas rendered sterile beneath tailings piles and brine ponds.

Construction and use of support facilities would have residual impacts in that the topsoil along the entire route of roads and railroads would be disturbed, mixed and altered, thus destroying the present microorganism community and soil-plant relationships. This would result in the loss of protective vegetation and induce increased erosional conditions, subsequent soil loss, and reduction of air quality. Heavy equipment would create compaction which would affect soil permeability and water infiltration rates, resulting in increased runoff, erosion, and sedimentation. The area used for roads and for railroad track ballast slopes would be lost to soil productivity for the period during which these support facilities are in use.

Support facilities such as gas lines, waterlines and powerlines would have basically the same residual impacts as roads and railroads, except that the term would be shorter in duration, once original construction is complete, because recover would occur sooner.

As a result of lease abandonment, surface disturbances which have altered soil structure, permeability, infiltration rates, compaction properties and vegetative cover at the existing operations would be stopped. When deposition of salt is stopped, and until detrimental effects from accumulation are reduced over a period of time, a low adverse impact would continue. After a period of time passes and soils have readjusted, a beneficial impact would be initiated because of reestablishment of an adapted vegetative community. This results from the curtailment of refinery particulates in effluent contaminants that previously affected soils. Construction disturbances would have stopped and soil surface microinterrelationships have been allowed to readjust. Abandonment would reduce the impacts of roads and railroads because the roads and railroad would be tornup and the area revegetated.

d. Minerals

Impacts of the proposed action on mineral resources would be partially mitigated by mitigating measures numbered: 20, 21, 40, 41, 42, 43, 44, and 45. The mining and processing of potassium-bearing ores would continue if the proposed action is approved, resulting in residual impacts in the depletion of nonrenewable mineral resources. In the next 20 years, an estimated 592 million short tons of potash ore will be mined or lost in mining in the Carlsbad mining district. This tonnage comprises about 16 percent of the total economic potash resource estimated to exist in the district, and as much as 45 percent of the economic resource of a higher grade. Residual impacts of lesser importance include use of aggregate in construction activities, the removal and stacking or entraining in brines of common salt associated with potash ore, and the delay and prevention in places of completion of test and development wells for oil and gas.

An undetermined amount of potash will be entrained in brines because of processing inefficiences. Effective sealing of ponds may enrich the brine in potassium salts and it is possible that at some time in the future this brine may be harvested.

e. Vegetation

Mitigating Measures 1, 3, 7, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 33, 34, 37, and 45, are designed to mitigate impacts on vegetation.

Exploration activities will cause the temporary loss of 300 to 400 acres of vegetation which will be revegetated in 1 to 5 years. Mine development will cause the relatively permanent loss of from 5 to 10 acres of vegetation per mine site. Refinery construction and operation will cause the direct, relatively permanent, loss of an estimated 580 acres of vegetation per refinery site. In addition, refinery operation will have a variable residual impact on an undetermined area of vegetation due to the refinery air emissions. This impact will range from slight discolorations of leaves through defoliation, mortality, species change to salt tolerant vegetation, and finally to total sterilization of the soil. The area involved will depend upon the effectiveness of future air emission control regulations. The maximum area involved is estimated to be a ¼ to ½ mile radius around each potash refinery assuming no air emission regulations are developed. The enactment of air emission regulations will reduce the area of impact by an unknown amount.

Construction and operation of refinery support facilities will cause the direct, relatively permanent, loss of an estimated 30 acres of vegetation and the temporary loss of an estimated 120 acres of vegetation per refinery. Lease abandonment will cause the existing air emissions and surface disturbing activity to cease. Under these conditions the mine site, the support facility area and all but the tailings piles and brine pond acres (500 acres) of the refinery sites should become revegetated once the toxic salt concentraions have been leached out of the active root zone for adapted vegetation.

f. Wildlife

The impacts of the proposed action and alternatives would be mitigated totally or in part by the following recommended mitigating measures: 1, 3, 7, 9, 10, 11, 12, 13, 14, 15, 18, 19, 22, 23, 24, 25, 26, 27, 33, 34, 37, 46. After implementation of these mitigating measures, the following would remain as residual impacts.

A certain amount of noise disturbance and habitat destruction will continue to occur as a result of exploration, mine development, refinery construction and operation and construction of support facilities. These would be slightly adverse short to long term impacts which would cease upon lease abandonment. Terrestrial wildlife habitat will be permanently destroyed on an estimated 500 acres per refinery site through the establishment of tailings piles and brine ponds. This will be a long term adverse impact but will be of minimal regional significance.

A moderately beneficial impact on big game species may continue to occur on a site specific basis through a vegetative species change to four wing saltbush. This is a preferred browse species. This species change occurs in limited areas of particulate fall out and may continue for the operating life of a refinery.

A potential exists for a significantly adverse impact on aquatic species as a result of implementation of mitigating measures to reduce or eliminate leakage from brine ponds. This could lead to the loss of aquatic habitat due to elimination of the water source. This would be a long term site specific impact.

g. Ecological Interrelationships

Impacts on ecological interrelationships will be mitigated by measures 1, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 23, 24, 25, 26, 27, 33, 34, 37, 40, and 46. After these measures are applied there will still be residual impacts resulting from disruption during all construction activities. Ecological processes will be destroyed or altered to some extent wherever construction occurs. The impacts from tailings piles and brine ponds would be permanent. A reduction in air emissions from the refineries will bring about some reduction in the impacts on ecological interrelationships related to salt accumulations in the soils the effects of the air emissions on vegetation, and the corresponding effects on wildlife and soil proteciton.

h. Aesthetics and Recreation

The impacts of the proposed action and alternatives on aesthetics, open spaces and recreation would be partially mitigated by the recommended mitigating measures numbered: 1, 2, 3, 8, 9, 10, 11, 12, 13, 15, 16, 18, 19, 22, 23, 24, 27, 31, 32, 33, 34, 35, 37, 45, and 46.

Assuming implementation of these mitigating measures, the residual adverse impacts of the proposed action or alternatives would consist of: the permanent loss of approximately 3,500 acres of land to recreational use through their use as tailings disposal sites; the creation of an undeterminable amount of unavoidable linear scars because of rights-of-ways; and the removal of new mining and refining sites from public use for their period of operation. A residual beneficial impact would result from the availability of new roads for improved hunter access and ORV use within the Study Area.

i. Cultural Resources

The impacts of the proposed action and alternatives on cultural resources will be partially mitigated by the implementation of mitigating measures 27, 28, 29, and 30. Assuming implementation of these mitigating measures, certain adverse residual impacts will remain.

Cultural values, even when salvaged, are destroyed. The very act of salvage involves the destruction of the site context. The information gained is limited by the techniques presently available. The development of a better technique at a later date is of no use once the site has been excavated since only materials of present informational value are saved. The site context is gone and no further information can be gained. If, for example, a method of determining sleeping areas from soil samples is discovered, it cannot be applied to those sites already excavated since no soil samples would have been saved for this purpose. The residual impact is the destruction of the site even when excavated by qualified archaeologists.

Avoidance of sites still involves a residual impact. Sites which are avoided by rights-of-way are still made more accessible to pothunters than if the right-of-way was never constructed. Cultural resources are irreplaceable and damage is done when they are disturbed in any manner. Abandonment still leaves the area accessible and in some areas pothunter traffic will actually increase.

j. Social Economic Conditions

The residual impacts on the economic base and social structure will be the same as the previously described impacts. See pages III-25 to III-36.

k. Land Use Compatibility & Suitability

The impacts of the proposed action or alternatives on land use compatibility and suitability would be mitigated in part by the implementation of mitigating measures numbered: 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 40, 45, and 46.

These mitigating measures would not totally eliminate any of the adverse impacts previously described, however, most of these impacts would be significantly reduced in severity. Probably the most significant residual impacts would be on the oil and gas industry and cultural resources. It is quite likely that oil and gas testing and production would still be delayed or forced to use directional drilling within the Study Area. Because of the lack of technology for drilling through second mined areas, this could quite possibly be a long-term impact.

As for cultural resources, it is obvious that not all sites within the area can be avoided during surface disturbing activities because of the density of sites. Even when a site is salvaged, its potential for yielding further information in the future is destroyed. This would obviously be a significantly adverse long-term and due to the present lack of archaeological knowledge about the area.

B. Short Term Use vs. Long Term Productivity

Assuming that 3.6 billion tons of potash ore exist, full-scale development of the potash industry in the Carlsbad Potash Basin will not significantly reduce long-term productivity. At the present time, the 7 operating companies are producing about 2,300,000 tons of finished product (K_2O equivalent) per year, and at that rate, the presently identified reserves would last for about 210 years. If this production were increased to the maximum amount which is foreseen at this time, there would be produced about 4,000,000 tons of finished product (K_2O equivalent) per year, and the presently identified reserves would last about 110 years.

It must be realized that several factors could dramatically modify the above data. These would include the overall economics of potash mining and refining, in order that lower grade ores could be utilized; changes in refining technology; changes in exports or imports of potash; changes in agricultural use of potash, etc.

Even at the higher rates of potash production, significant acreages of land surface would not be removed from other resource uses. At the present time, the 7 operating companies are utilizing 4,025 acres out of the 969,875 acres in the Study Area, or 4/10 of one percent.

From the standpoint of productivity, the entire Study Area is currently useful for producing livestock and wildlife forage. The extent to which forage production is or will be impaired as a result of potash mining, is a very small amount.

C. Irreversible and Irretrievable Commitments of Resources

1. Mineral Resources

The major commitment of resources is the mining and consumption of 50 to 80 million tons of potash (K_2O equivalent) in the next 20 years. This represents about 10 to 18 percent of the known present, economically mineable potash reserves in the Study Area. In certain parts of the Study Area there are rather substantial tonnages of potash that have not been, and will not be recovered. This occurs in an area around all mine shafts, underneath refineries, around oil wells, and the ore which remains as a pillar after mining. The total amount of this ore is unknown. There is also a rather significant amount of potash which is permanently lost as a part of the brine which is pumped onto the tailings piles. Even though the amount of potash contained in this brine is low (± 2%), when the tailings from all 7 refineries are considered over a year's period of time, about 270,000 tons of potash are lost each year in this manner.

Large amounts of sand, gravel, and other types of aggregate material will be used, and for all practical purposes, is irretrievable. The total amount to be used in the Study Area is unknown.

Large volumes of natural gas are consumed by the 7 operating potash refineries in the Study Area, which is a long-term irreversible commitment of this resource. The average annual consumption of gas for all seven refineries totals about 8,000,000 MCF. The average consumption per ton of finished product is about 1.73 MCF. If the potash industry expands, correspondingly larger volumes of natural gas will be needed.

2. Water Resources

Water that is presently consumed by the 7 operating potash companies in the Study Area, originates from 3 sources:

Caprock	8500 acre feet per year
Capitan Reef	3500 acre feet per year
Rustler Formation	900 acre feet per year
TOTAL	12,900 acre feet per year

This constitutes a long-term commitment of water resources that is irreversible for as long as the potash refineries exist, unless a different source of water is located. Some of the companies have additional water rights which are not presently being utilized. This water would be available to use for expansion of the potash industry. The total amount of water that is currently appropriated by the potash industry is 22,500 acre feet per year from the Caprock, 3,500 acre feet from the Capitan Reef, and 4,500 acre feet from the Pecos River. The average consumption of fresh water per ton of finished product is 1,260 gallons.

3. Cultural Resources

Any destruction of historical, archaeological, or paleontological values will be an irreversible commitment of these resources. It is estimated that there are about 12 to 15 archaeological sites per square mile in the study area. The average Refinery would cover about 730 acres, including the refinery, salt tailings pile, brine pond, and support facilities such as roads, railroads, waterlines, power lines, natural gas lines, etc. Obviously any new refineries and related facilities would result in a substantial irreversible and irretrievable loss of cultural resources.

Any sites mitigated by salvage rather than avoidance, are also irreversibly lost, since they will be destroyed in the process of salvage and will not be available for future research.

4. Aesthetics

The visual character of the Study Area is currently one of broad open spaces, intermixed with concentrations of mining and industrialization.

5. Electricity

Large quantities of electrical power are required for the 7 operating potash mines and refineries. The average annual consumption of electric power for all 7 potash mines and refineries totals about 400,000,000 KWH. This is a long-term, irreversible commitment of this resource, and if the industry expands, correspondingly larger quantities of electricity will be needed. At the present time, the industry requires an average of about 81.75 KWH per ton of finished potash product.

6. Loss of Fuels and Materials

Extraction of potash, construction of railroads, roads, power lines, waterlines, gas lines, refineries, and other facilities will require large commitments of fossil fuels, manpower, machinery, iron, steel, conveyor belts, and a myriad of lesser items such as blasting materials, etc. This material and effort will be irretrievably lost to other uses.

7. Loss of Human Life

Fatal accidents will occur, which are related directly to the physical activity of potash mining and refining, and are considered on-the-job accidents. There will also be secondary causes of human life losses, which occur as an indirect result of mining activity. These are the traffic accidents, train accidents, and possibly murders and suicides resulting from increased human interaction from population increases. The only data which is available on this subject, relates to fatalities which have occurred in the potash mines and refineries during the years 1973 and 1974. There were four fatalities each year. All of these losses of human life would constitute an irreversible and irretrievable commitment of human resources attributable to potash development.

8. Loss of Land

Each of the 7 operating potash companies has a large salt tailings pile and a brine pond adjacent to the refinery. These constitute a rather sizable permanent irreversible and irretrievable commitment of the land surface involved. The average new refinery will use an estimated 500 acres for tailings piles and brine ponds. This land is lost forever, from the standpoint of vegetation production, livestock forage, wildlife habitat, recreation, and other land uses. These salt piles may also continue to spread out and cover more land area over an infinite period of time, from the effect of rainfall.

The only land use which can be quantified is the loss of livestock forage. Assuming that the 7 refineries presently remove 4,000 acres from vegetation production, this would constitute a permanent loss of enough range to support 50 cattle on a year-long basis.

IV. Persons, Groups, and Government Agencies Consulted

Air Pollution Technical Information Center,
U. S. Environmental Protection Agency,
Research Triangle Park, North Carolina

Air Quality Division,
New Mexico Environmental Improvement Agency,
State of New Mexico,
Santa Fe, New Mexico

AMAX Chemical Corp.
National Potash Corp.
Kerr McGee Chemical Corp.
Duval Corporation
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Carol Chavez
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Environmental Data Services,
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Carlos Gallegos
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Mr. T. M. Wright,
Division Engineer's Office
Santa Fe Railroad
Clovis, New Mixico

Mr. Joe Yates
State Engineer's Office
Santa Fe, New Mexico

V. Intensity of Public Interest

Because of public interest in the Preliminary Regional Potash Environmental Analysis Record, a public meeting is scheduled after publication and review. Comments presented at this public meeting will be summarized and included in the final Regional Potash Environmental Analysis Record.

VI. Participating Staff

1	Paul Bodenberger Bureau of Land Management	Environmental Analyst Writer
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2	Donald Calhoun Bureau of Land Management	Surface Protection
	Georgia Davis Bureau of Land Management	Typist
3	Charles Godfrey Bureau of Land Management	Aesthetics, Recreation, History
4	Stella Gonzales Bureau of Land Management	Lands Adjudication
5	Carol O. Herron Bureau of Land Management	Writer/Editor
6	J. L. Kunkler Geological Survey	Hydrologist
7	William Leifeste Bureau of Land Management	Vegetation
8	Ann Loose Bureau of Land Management	Archaeology, Paleontology
9	Miguel M. Martinez Bureau of Land Management	Socio-Economics, Land Use
10	Raul Martinez Bureau of Land Management	Minerals Adjudication
11	Marvin Millgate Geological Survey	Minerals Specialist
	Bob Nelson, Ph. D. University of Oklahoma	Air Specialist
12	Joe B. Rosenbaum Bureau of Mines	Mining Consultant
13	Verlyn Saladen Bureau of Land Management	Soil Scientist

Participating Staff

Yolanda Sanchez Bureau of Land Management	Typist
14 Robert Schmidt Bureau of Land Management	Team Leader Regional Planner
15 Gerald Sintz Bureau of Land Management	Wildlife Specialist

DEVELOPMENT OF THE CLIMATOLOGICAL DISPERSION MODEL INCLUDING FALL VELOCITIES AND DEPOSITION

The basic climatological dispersion model, C.D.M. is described in detail by Busse (1973). Briefly, the model allows pollutants to spread uniformly over arcs of $22\frac{1}{2}^{\circ}$ in the horizontal while maintaining a Gaussian distribution in the vertical. This model can be utilized to estimate surface concentrations of pollutant averaged over a long time period, say a month or a year, but is incapable of estimating short period concentrations due to the assumptions involved in developing the model. One of the assumptions is that, over a long period of time, pollutant dispersed to areas outside the $22\frac{1}{2}^{\circ}$ arc when the wind is advecting pollutant within the arc is replaced by dispersion from other arcs. The other assumption is that the concentration is uniform within each arc at a given distance from the source (Turner, 1970).

The basic C.D.M. has been formulated as:

$$C_p = \frac{16}{2\pi} \sum_{n=1}^{N} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \frac{\phi(K_n, \ell, m)\, G_n\, S\,(\rho_n, z, U_\ell, P_m)}{P_n}$$

$C_p \equiv$ average concentration due to point sources

$\phi\,(K_n, \ell, m) \equiv$ joint frequency function

This function represents the frequency with which the wind direction class K_n, the wind speed class ℓ and the stability class m occur. The function is computed using the National Climatic Center STAR program.

$G_n \equiv$ emission rate of the nth point source

$S\ (\rho_n, z, U_\ell, P_m) \equiv$ dispersion function

$\rho_n \equiv$ distance from receptor to the nth point source.

$z \equiv$ height of receptor above ground level

$U_\ell \equiv$ representative wind speed

$P_m \equiv$ Pasquil stability category

$\sigma_z\ (\rho) \equiv$ vertical standard deviation of the pollutant concentration, dependent upon the Pasquil stability class as well as distance from the source. $\sigma_z\ (\rho) = a\rho^b$; a and b are empirically determined for various distance classes from the source if the receptor is located at ground level ($z=0$), $\sigma\ (\rho) \leq .8L$, and there is no atmospheric scavenging of the pollutant, then

$$S\ (\rho, 0, U_\ell, P_m) = \frac{2}{\sqrt{2\pi}\ U_\ell\ \sigma_z\ (\rho)}\ \exp \left[-\tfrac{1}{2}\ \frac{h}{\sigma_z(\rho)} \right]^2$$

h = effective stack height of the source distribution

$h = H + \Delta h$

$H \equiv$ physical height of the source (meters)

$\Delta h \equiv$ plume rise (due to buoyancy and initial exit velocity from the stack) (meters)

$\Delta h = 1.6F^{1/3} U_\ell^{-1}\ \rho_n^{2/3}$ if $\rho \leq 3.5\ x^*$

$\Delta h = 1.6F^{1/3} U_\ell^{-1} (3.5\ x^*)$ if $\rho > 3.5\ x^*$

The ρ / x^* is not allowed to exceed 3.5, as suggested by Briggs (1971).

$x^* = 14F^{5/8}$ if $F \leq 55$

$x^* = 34F^{2/5}$ if $F > 55$

$F = gVeRs^2\ (Ts - Ta)/Ts$

$g \equiv$ acceleration due to gravity (m/sec^2)

Ve $\equiv$ average exit velocity from plume, m/sec

Rs $\equiv$ inner stack radius (m)

Ts $\equiv$ av.effluent temp. (^{o}K)

Ta $\equiv$ ambient temp (^{o}K)

if $\sigma_z(\rho) > .8L$

$S\ (0, U_\ell, P_m) = \frac{1}{U_\ell L}$

L $\equiv$ mixing height

The climatological mean mixing height, stability dependent, is determined with the aid of E.P.A. publication no. AP-101 Holzworth (1972).

The above formulation is utilized if the fall velocity is negligible and no deposition occurs.

The fall velocity is generally considered negligible for gases and particulate metter less than twenty microns in diameter. For, spherical particles greater than 20μ the fall velocity may be estimated using Stokes' equation for terminal settling. Hesketh (1972).

$$V_s = \frac{2\, r_p^2\, g\, \rho_p}{9\, \mu_a}$$

V_s $\equiv$ terminal velocity

r_p $\equiv$ particle radius

ρ_p $\equiv$ particle density

μ_a $\equiv$ air viscosity

g $\equiv$ gravitational acceleration

When gravitational settling must be accounted for the C.D.M. is modified so that the effective stack height is

$h \equiv H + \Delta h - V_s\, \rho_n / U_\ell$.

(ρ_n / U_ℓ represents the travel time from the source)

Since the settling rate is very sensitive to particle size, a large number I, of size classes must be used, and an accurate accounting of the fraction, P(i) in each size range obtained. The modified C.D.M. becomes:

$$C_p = \frac{16}{\pi} \sum_{n=1}^{N} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \sum_{i=1}^{I} \frac{\phi(k_n, \ell, m)\ p\ (i)\ G_n\ S\ (\rho_n, z, U_\ell, P_m, V_s)}{\rho_n}$$

The C.D.M. must be further modified in order to account for deposition, w, defined as:

$w \equiv v_s\ C_p$

A virtual source strength Q* must be defined to account for prior deposition. Q* is the mass of pollutant which would have to be emitted from the source per unit time in order to produce the concentration observed at the distance ρ_n from the source if no deposition had occurred upwind. Computation of Q* will account for the upwind deposition.

For the case where $\sigma_z\ (\rho) \leq .8L$, replace $\phi(K_n, \ell, m)\ p\ (i)\ G_n$ with the dummy variable Q. Looking only at the nth source, ℓth windspeed class, etc.,

$$W = \frac{8}{\pi} \quad \frac{V_s(i)Q}{\rho_n} \quad \frac{2}{\sqrt{2\pi}\, U_\ell\, \sigma_z\,(\rho)} \quad \exp\left[-\tfrac{1}{2} \quad \frac{h}{\sigma_z(\rho)}\right]^2 ,$$

Depletion of the source per unit distance is

$$\frac{\partial Q}{\partial \rho} = -\int_{-\infty}^{\infty} w\ ds = -\int_{0}^{\pi/8} w\ \rho_n d\alpha$$

$$= -\frac{2V_s(i)Q}{\sqrt{2\pi}\ U_\ell \sigma_z(\rho)} \exp\left[-\tfrac{1}{2}\ \frac{h}{\sigma_z\ (\rho)}\right]^2$$

$$\int_{Q_o}^{Q^*} \frac{dQ}{Q} = -\int_{0}^{\rho_n} \frac{2V_s(i)}{\sqrt{2\pi}\ U_\ell\ \sigma_z(\rho)} \exp\left[-\tfrac{1}{2}\ \frac{h}{\sigma_z(\rho)}\right]^2$$

$$\ln \frac{Q^*}{Q_o} = \frac{2V_s(i)}{\sqrt{2\pi}\, U_\ell} \; I$$

$$I \equiv \int_0^{\rho_n} \frac{\exp\left[-\frac{1}{2}\left(\frac{h}{\sigma_z(\rho)}\right)\right]^2}{\sigma_z(\rho)} \, d\rho$$

The integral may, be computed numerically using the trapazoidal rule.

$$Q_o \equiv \phi(K_n, \ell, m) \; p(i) \; G_n$$

$$\therefore Q = Q_o \exp\left[-\frac{2V_s(i) \; I}{\sqrt{2\pi}\, U_\ell}\right]$$

Substituting for Q and Q_o,

$$C_p = \frac{8}{\pi} \sum_{n=1}^{N} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \sum_{i=1}^{I} \frac{\phi(K_n, \ell, m)\; p(i)\; G_n}{\rho_n} \; \frac{2}{\sqrt{2\pi}\, U_\ell \, \sigma_z(\rho)}$$

$$\exp\left[-\frac{1}{2} \frac{h}{\sigma_z(\rho)}^2\right] \quad \exp\left[-\frac{2V_s(i) \; I}{\sqrt{2\pi}\, U_\ell}\right] ,$$

In a similar fashion, it may be determined that for $\sigma_z(\rho) > .8L$,

$$Q_1^* = Q^* \exp\left[-\frac{V_s(i)}{U_\ell \, L} \; (\rho_n - \rho_1)\right]$$

ρ_1 the distance from the source at which

$\sigma_z(\rho) = .8L$

Q* is the virtual source strength of ρ_1, determined in the manner described above.

In this case:

$$c_p = \frac{8}{\pi} \sum_{n=1}^{N} \sum_{\ell=1}^{6} \sum_{m=1}^{6} \sum_{i=1}^{I} \left\{ \frac{\phi(K_n, \ell, m)\ p(i)\ G_n}{\rho_n U_\ell L} \exp\left[- \frac{2V_s(i)\ I}{\sqrt{2\pi}\ U_\ell} \right] \exp\left[- \frac{V_{s(i)}}{VeL} (\rho_n - \rho_1) \right] \right\}$$

The average deposition may be determined at each point from the definition:

$$\therefore W = \sum_{c=1}^{I} V_s(i)\ C_p\ (i)$$

where C_p (i) is the concentration for the ith particle size class.

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL MISSISSIPPI CHEMICAL CORPORATION

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
1 Dryer Stack	42	1.5	400° est.	46	464

APPENDIX A-2

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL AMAX CHEMICAL CORPORATION

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
1.	33	3.0	325°	90.5	102
2.	33	3.0	325°	90.5	102
3.	20	3.0	325°	90.5	386
4.	57	2.0	68.2°	73.7	530
5.	43	1.5	68.2°	69.7	256
6.	64	1.3	68.2°	74.6	208.8
7.	64	1.3	68.2°	74.6	208.8
8.	64	1.3	68.2°	74.6	208.8
9.	34	1.8	368.2°	74.6	208.8
10.	34	1.8	368.2°	74.6	208.8
11.	34	1.8	368.2°	74.6	208.8

APPENDIX A-2

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL INTERNATIONAL MINERALS CORPORATION

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
9 Ozark Evaporators	19 ea.	4.0 ea.	198° ave.	68'	2448 total
Muriate # 1 Dryer	60	2.5	290°	55	525
Muriate # 2 Dryer	60	2.5	290°	90	525
Muriate # 3 Dryer	47	3.0	290°	75	1500
Langbeinite Dryer # 1	80	4.0	390°	80	1200
Langbeinite Dryer # 2	60	2.5	390°	55	500
Sulphate Dryer	90	2.5	290°	85	2000
4 Raymond Mill Crushers	20 ea.	1.5 ea.	190°	75 ea.	800 total

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL
POTASH COMPANY OF AMERICA

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
3 Standard Product Dryers	48 ea.	3.5 ea.	400°	85 ea.	1005 total
2 Granular Dryers	63 ea.	2.0	320°	95	444 total
2 Chemical Product Dryers	60 est.	1.5	290°	40	800 total
Soluble Product Dryer	48 est.	1.5	290°	45	450
Screening Sources # 1	44	1.5	76°	40	360
Sources # 2	12	1.0	76°	60	10
Sources # 3	30	3.5	200°	80	900
Sources # 4	60	2.0	76°	60	100

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL
DUVAL CORPORATION

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
1.	41	3.2	355°	75	350
2.	55	3.2	345°	85	350
3.	30	1.0	305°	55	182
4.	62	1.1	145°	60	113
5.	53	1.8	190°	50	200
6.	38	1.2	145°	80	117
7.	37	1.8	298°	100	383
8.	18	1.0	200°	80	123
9.	56	1.1	180°	80	123
10.	37.5	1.2	212°	80	274
11.	32	3.8	375°	90	350
12.	55 est.	3.0	350° est.	90	90

APPENDIX A-2

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL NATIONAL POTASH CORPORATION

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
1.	24	3.5	675°	71	2
2.	28	2.0	440°	27	1
3.	55	2.5	400°	76	31
4.	63	2.5	400°	75	38
5.	37.6	2.0	200°	51	10
6.	37.6	2.0	200°	46	10
7.	60	1.3	210°	76	5
8.	78.5	1.3	100°	40	31

INPUT INFORMATION FOR CLIMATOLOGICAL DISPERSION MODEL KERR-MC GEE CORPORATION

Source	Effluent Velocity Ft./Sec.	Stack Diameter Ft.	Effluent Temperature F	Stack Height Ft.	Emission Strength Tons/yr.
1.	32	3.7	65°	35	3
2.	32	3.7	65°	35	3
3.	32	3.7	65°	35	3
4.	134	2.0	360°	93	34
5.	48	2.5	100°	60	400
6.	60	2.5	77°	5	22

APPENDIX A-3

STATE OF NEW MEXICO
Environmental Improvement Agency
P.O. Box 2348, Santa Fe, New Mexico 87503

☐ AIR QUALITY DIVISION

September 19, 1975

Dr. Larry Canter
1322 Cherry Laurel Dr.
Norman, Oklahoma 73069

Dear Dr. Canter:

Enclosed are data reports for three high-volume sampling sites located outside urban areas in sourthern New Mexico. The site location is roughly identified on the sheets. I can provide exact locations for each site if you wish to have them. The mean value listed on the SOROAD array is an arithmetic mean while that on the graphic is a geometric mean. I regret that no graphic is available for the site near Las Cruces.

Please note that one of the sites is east of Carlsbad. Unfortunately, this sampling site has been discontinued and I can give you only four months of data (only 13 24-hour samples). I think this site is about five miles from the IMCC potash mill but the actual coordinates are given at the top of the SOROAD printout. For the available data at this site, the arithmetic mean was 45.9 and the geometric mean was 37.0. However, the samples were taken during the period of September thru December. Compare the values at the other two non-urban sites during the same time period. One might speculate that the expected higher values for the period of March thru July would increase the annual means considerably--probably above 60 $\mu g/m^3$. Since the site is fairly close to IMCC, one might also speculate that the observed higher values for this site (as compared to the other two-non-urban sites) is partly due to the effects of the potash industry.

In any case, I believe that the enclosed data supports your use of a value of 40 $\mu g/m^3$ for a background annual mean. Please contact me if I may provide additional information.

Sincerely,

Kenneth M. Hargis
Program Manager
Program Development & Planning Section

KMH:lo

AIR QUALITY DATA REPORT

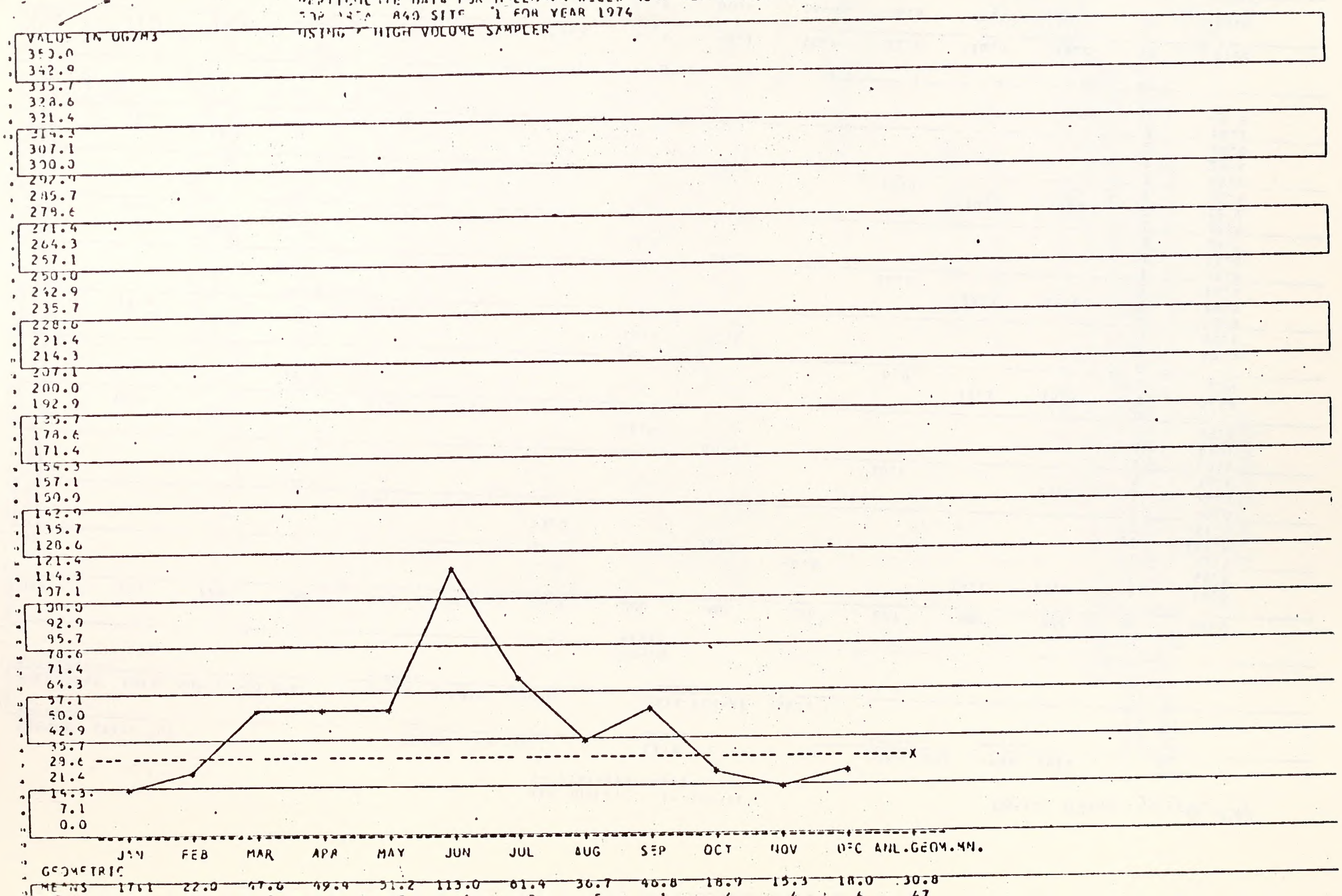
Near Alamogordo, NM

AGENCY STATE AGENCY STATE NEW MEXICO CITY ALAMOGORDO-6[illegible] SITE 001 YEAR 1974

POLLUTANT TOTAL SUSPENDED PART. UNITS U GM/M3 (0DEG) DATA FORMAT XXX.X

	MONTH													
DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N	MEAN
01											18.1	19.8	2	19.0
02									46.8				1	46.8
03								52.5					1	52.5
04						113.0							1	113.0
05				33.6	69.4								2	51.5
06			35.0										1	35.0
07												24.3	1	24.3
08										30.1			1	30.1
09								60.4					1	60.4
10		18.2					62.0						2	40.1
11	15.9			47.6	51.2								3	38.2
12													0	
13			51.9								13.3	15.3	3	26.8
14										6.9			1	6.9
15													0	
16		20.8					56.1	50.1					3	42.2
17	17.4			69.0	51.8								3	46.1
18			52.9										1	52.9
19											22.3	30.6	2	26.5
20										16.6			1	16.6
21								27.5					1	27.5
22		22.4					66.6						2	44.5
23	16.0			72.9	55.2								3	48.0
24			32.9										1	32.9
25											10.2	15.0	2	12.6
26										36.8			1	36.8
27								15.2					1	15.2
28		28.4											1	28.4
29	19.4			36.6									2	28.0
30			77.4		34.8								2	56.1
31												9.9	1	9.9
N	4	4	5	5	5	1	3	5	1	4	4	6	47	
MN	17.2	22.3	50.0	51.9	52.5	113.0	61.6	41.1	46.8	22.6	16.0	19.2	47	37.2
MX	19.4	28.4	77.4	72.9	69.4	113.0	66.6	60.4	46.8	36.8	22.3	30.6	47	113.0

PARTICULATE DATA FOR HOLLOMAN WELLS NEAR ALAMOGORDO-[illegible]
[illegible] 840 SITE 1 FOR YEAR 1974
USING [illegible] HIGH VOLUME SAMPLER



Near Las Cruces

AIR QUALITY DATA REPORT

AGENCY STATE AGENCY STATE NEW MEXICO CITY DONA ANA CO.-CK SITE 005 YEAR 1974

POLLUTANT TOTAL SUSPENDED PART. UNITS U GM/M3 (00EG) DATA FORMAT XXX.X

MONTH

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N	MEAN
01											7.0	28.4	2	17.7
02									51.4	23.0			2	37.2
03								24.5				12.9	2	18.7
04						64.0	95.3						2	79.7
05	27.2			33.9	66.6								3	42.6
06			32.9										1	32.9
07											17.0	16.5	2	16.8
08					80.0				50.5	15.9			3	48.8
09								22.5					1	22.5
10		23.6				55.7	24.2						3	34.5
11	10.6			78.2	42.6								3	43.8
12			31.7										1	31.7
13											25.0	13.2	2	19.1
14									51.3	6.9			2	29.1
15								24.3					1	24.3
16		40.1				44.3							2	42.2
17	21.8				69.1		22.3						3	37.7
18			87.3										1	87.3
19											22.1	28.1	2	25.1
20									11.6	16.2			2	13.9
21								17.3					1	17.3
22		16.0				84.3							2	50.2
23	4.5			106.9	47.9								3	53.1
24			29.7										1	29.7
25											27.7	14.6	2	21.2
26									12.5	16.5			2	14.5
27								7.1					1	7.1
28		40.3				162.7	82.0						3	95.0
29	16.3			49.3	48.8								3	38.1
30			53.6										1	53.6
31												28.1	1	28.1
N	5	[illegible]	5	4	6	5	4	5	5	5	5	7	60	
MN Mean	16.1	30.0	47.0	67.1	59.2	82.2	56.0	19.1	35.5	15.7	19.8	20.3	60	38.1
MX Max	27.2	40.3	87.3	106.9	80.0	162.7	95.3	24.5	51.4	23.0	27.7	28.4	60	162.7

W 103° 52' 30"

N 32° 25' 00"

East of Carlsbad

AIR QUALITY DATA REPORT

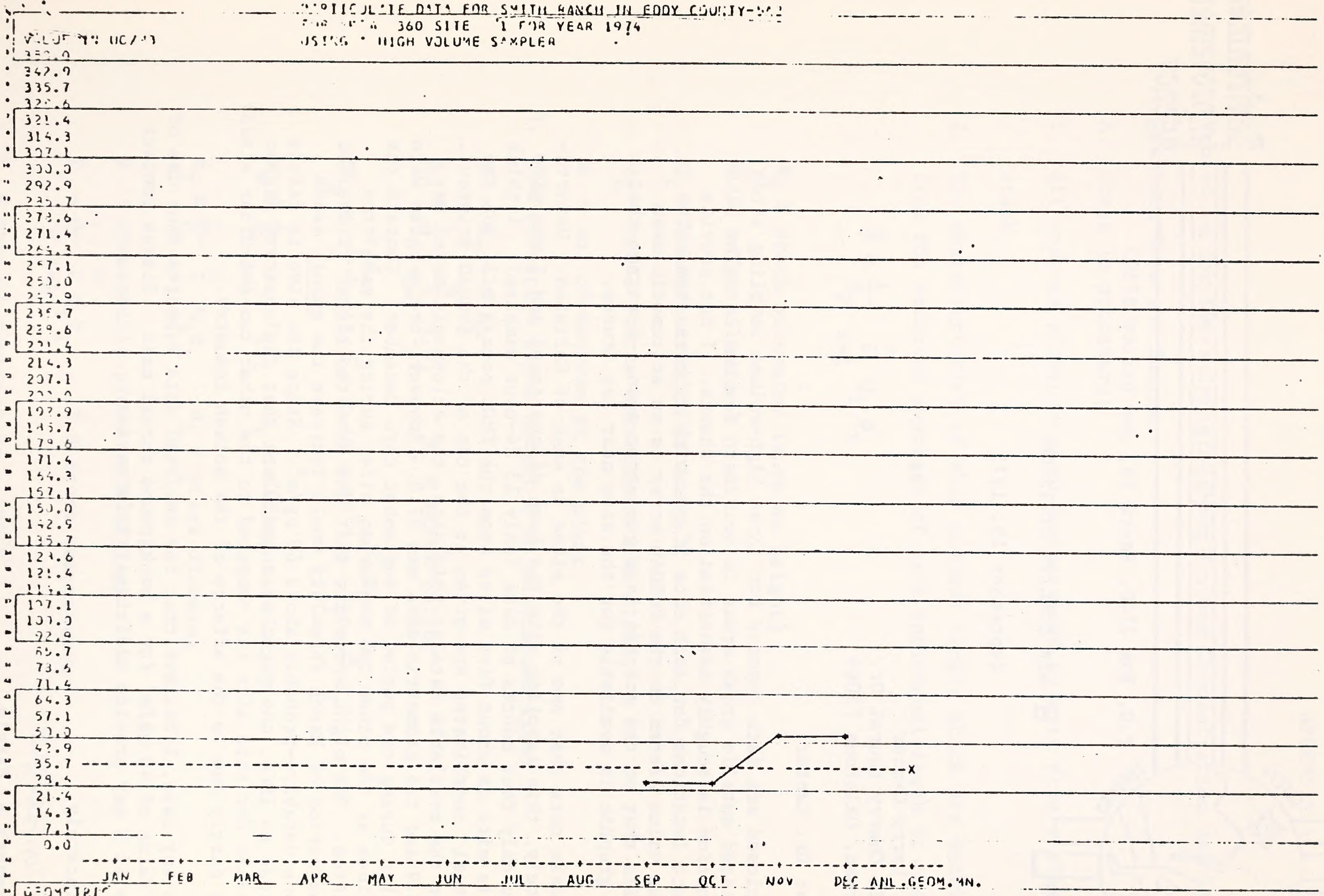
AGENCY STATE AGENCY   STATE NEW MEXICO   CITY EDDY COUNTY-548   SITE 001   YEAR 1974

POLLUTANT TOTAL SUSPENDED PART.   UNITS U GM/M3 (005G)   DATA FORMAT XXX.X

MONTH

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	N	MEAN
01												33.7	1	33.7
02										42.9			1	42.9
03													0	
04													0	
05													0	
06													0	
07											13.7	62.0	2	37.9
08										32.6			1	32.6
09													0	
10													0	
11													0	
12													0	
13											133.5	58.3	2	95.9
14									63.5	28.6			1	63.5
15													0	
16													0	
17													0	
18													0	
19											38.2		1	38.2
20									15.3				1	15.3
21													0	
22													0	
23													0	
24													0	
25											67.4		1	67.4
26									18.6	16.9			2	17.8
27													0	
28													0	
29													0	
30													0	
31													0	
N									3	3	4	3	13	
MN									32.5	30.8	63.2	51.3	13	45.9
MX									63.5	42.9	133.5	62.0	13	133.5

PARTICULATE DATA FOR SMITH RANCH IN EDDY COUNTY-NM
[illegible] 360 SITE 1 FOR YEAR 1974
USING A HIGH VOLUME SAMPLER



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANL.GEOM.MN.
GEOMETRIC MEANS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.2	28.7	46.6	49.6	37.0
NUM	0	0	0	0	0	0	0	0	3	3	3	3	13
MAXS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	63.5	42.9	133.6	62.0	133.5
MINS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	16.9	13.7	33.7	13.7

STATE OF NEW MEXICO
Environmental Improvement Agency
P.O. Box 2348, Santa Fe, New Mexico 87503

☐ AIR QUALITY DIVISION

September 19, 1975

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1322 Cherry Laurel Dr.
Norman, Oklahoma 73069

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Please note that one of the sites is east of Carlsbad. Unfortunately, this sampling site has been discontinued and I can give you only four months of data (only 13 24-hour samples). I think this site is about five miles from the IMCC potash mill but the actual coordinates are given at the top of the SOROAD printout. For the available data at this site, the arithmetic mean was 45.9 and the geometric mean was 37.0. However, the samples were taken during the period of September thru December. Compare the values at the other two non-urban sites during the same time period. One might speculate that the expected higher values for the period of March thru July would increase the annual means considerably--probably above 60 $\mu g/m^3$. Since the site is fairly close to IMCC, one might also speculate that the observed higher values for this site (as compared to the other two-non-urban sites) is partly due to the effects of the potash industry.

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Sincerely,

Kenneth M. Hargis
Program Manager
Program Development & Planning Section

KMH:lo

APPENDIX A 4

Procedure for Determining 24-Hour Maximum Concentration and its Distance from the Source.

A. Steps in procedure:

1. All sources within a plant are assumed to emit from a single stack.

2. The characteristics of this assumed single stack are determined from the weighted averages of each individual stack at the plant.

$$\bar{\phi} = \frac{1}{Q_T} \sum_{i=1}^{n} Q_i \phi_i$$

$\phi_i \equiv$ stack parameter (such as height)

$\bar{\phi} \equiv$ weighted mean

$Q_i \equiv$ source strength of stack i

$Q_T =$ total source strength of the plant

$n =$ no. of sources at the plant

3. The effective stack height H is determined from:

$$H = h_T + \Delta h_T$$

$$h_T \equiv \frac{1}{Q_T} \sum_{i=1}^{n} Q_i h_i \qquad h_i \equiv \text{stack height}$$

$$\Delta h_T = \frac{v_s d_T}{u} \left(1.5 + 2.68 \times 10^{-3}\, p\, \frac{T_s - T_a}{T_s}\, d_T\right)$$

$$v_s \equiv \frac{1}{Q_T} \sum_{i=1}^{n} Q_i v_i \qquad v_i \equiv \text{effluent velocity}$$

$$d_T \equiv \frac{1}{Q_T} \sum_{i=1}^{n} Q_i d_i \qquad d_i \equiv \text{stack diameter}$$

$p =$ atmospheric pressure $\equiv 1013$ mb

$$T_s = \frac{1}{Q_T} \sum_{i=1}^{n} Q_i T_i \qquad T \equiv \text{stack temperature}$$

$T_a \equiv$ ambient temperature $= 290^\circ$K

B. Results of procedure

Weighted Mean Quantities

Plant	h_t (m)	V_s (m/sec)	d_t (m)	T_s (°k)	Q_T (μg/sec $\times 10^6$)
IMC	24.62	16.1	.9366	408.42	273.8
AMAX	23.59	13.55	.5978	364.76	75.78
DUVAL	24.3	14.4	.712	419.5	76.54
PCA	20.45	14.6	.763	408.45	117.29
National Potash	21.93	18.25	.735	431.6	3.69
Kerr McGee	23.55	8.64	1.14	358.44	9.08
Mississippi Chem	14.03	12.81	.458	477.44	13.37

Effective Height, Maximum Concentration and Distance from the Source

Plant	H (m)	χ_m* (μg/m^3)	Distance (km)	Stability
IMC	30.25	>1000	.57	D
	35.88	>1000	2.	F
AMAX	26.06	>1000	.47	D
	28.54	>1000	1.5	F
DUVAL	27.88	823	.52	D
	31.46	943	1.8	F
PCA	24.35	>1000	.42	D
	28.25	>1000	1.5	F
National Potash	26.75	105	.48	D
	31.56	98	1.8	F
Kerr McGee	26.98	104	0.50	D
	30.41	117	1.70	F
Mississippi Chem	15.97	479	.28	D
	17.92	575	.82	F

*χ_m does not include background concentration.

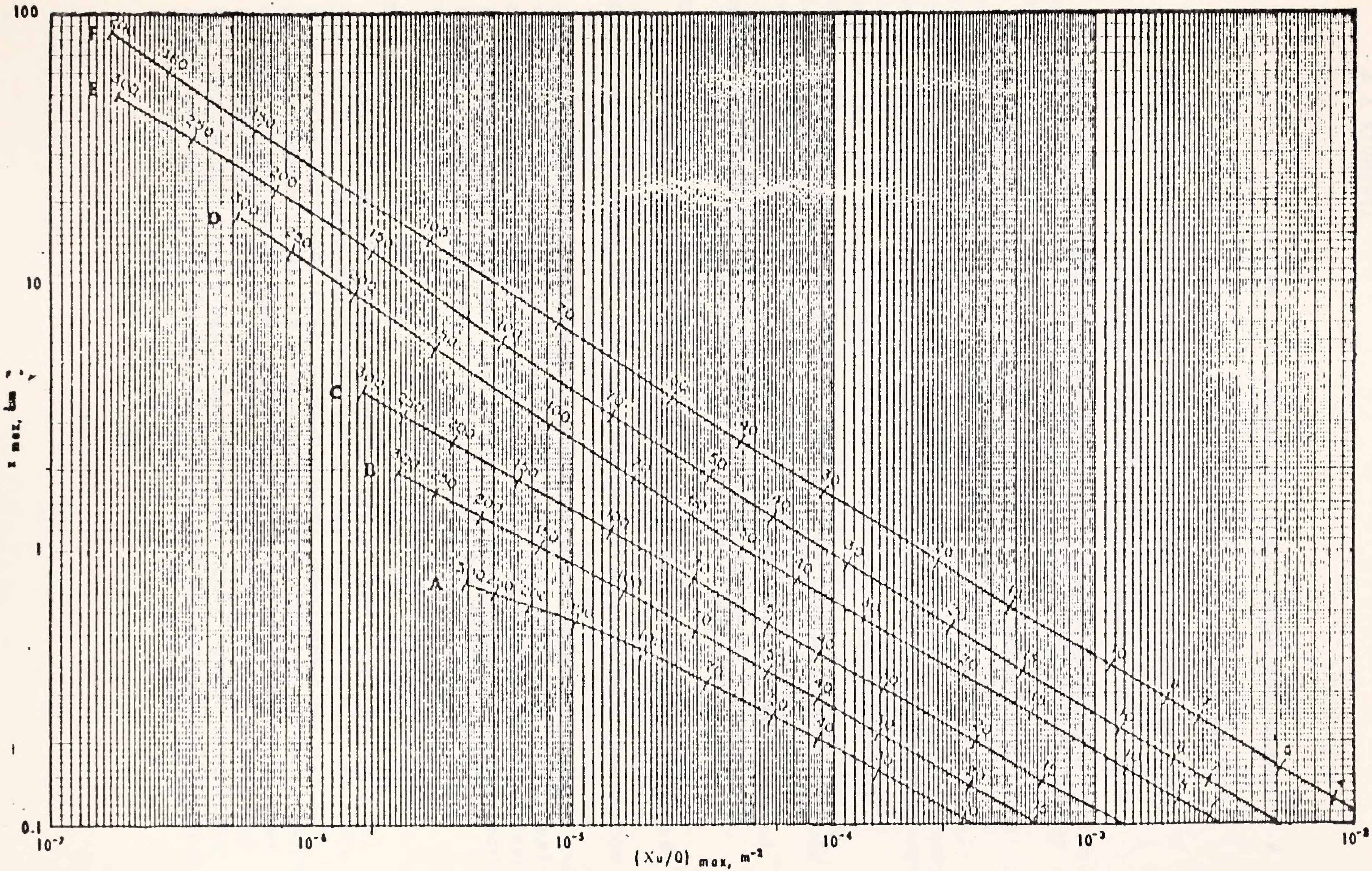

FIGURE Distance of maximum concentration and maximum xu/Q as a function of stability (curves) and effective height (meters) of emission (numbers)

4. Compute the effective stack height for neutral (D) stability and for stable (F) conditions.

   For very stable conditions use wind speed u = 3 m/sec (from figure 55, Holzworth). There have been cases observed where the mixing height was less than 1000 m and wind speeds between 2 and 4 m/sec for more than 24 hours.

   For neutral stability use u = 6 m/sec (from figure 20, Holzworth). This is the minimum mean seasonal wind speed averaged through the afternoon mixing layer.

5. Determine $(x\ u/Q)_{max.}$ and distance of maximum concentration from the source (in kilometers) for the D and F stability conditions using figure (see attached).

6. The concentration obtained using the parameter (x u/Q) max is based on a ten minute averaging period. To determine the maximum twenty-four hour concentration X_m the meander of the wind must be taken into account as follows:

$$X_m = X \left(\frac{.167\text{ hr}}{24\text{ hr}}\right)^{.17}$$

CHAPTER X

DUST AND DUST STORMS

An unattractive feature of New Mexico's climate is the dust storm. However, such storms vary greatly in intensity, in the areas they affect, in duration, and in time of occurrence.

The basic conditions for blowing dust are the presence of wide areas of exposed dry topsoil and strong, turbulent wind. In New Mexico, dry soil with scanty vegetation cover is widespread in areas that average less than ten inches of rain a year; in the Chaco basin of the northwest, over the dry southwestern plains, the trough of the Rio Grande, and such broad, dry basins as the Jornada del Muerto and the Tularosa depression. The Pecos Valley and the Staked Plains, though they receive heavier rainfall, nevertheless have scanty vegetation cover. The large tracts of sand hills, one series to the east of the Pecos River and another on the Staked Plains to the south of Clovis, are evidence of the effect of wind action on loose soils in the southeastern sector of New Mexico.

DUST STREAMS

Given the presence of loose soil, the severity of blowing dust depends on the strength and turbulence of the wind. In the dry months of late fall, winter, and early spring, a common phenomenon (not dignified by the name "dust storm") is the swift motion of dust and sand in wandering sheets and narrow streams. The dust and sand bounce and skip along the surface, and the mass of the material appears to be concentrated in a shallow layer less than two feet in thickness. Such local dust movements are caused by sudden, horizontal sweeps of air moving at speeds of fourteen to eighteen miles per hour.

DUST DEVILS

In contrast to the ground-hugging dust streams are the vertical dust devils. These small vortices of rapidly moving air, made visible by the dust and loose organic matter they sweep up, are especially common in sparsely vegetated, flat and open parts of southern New Mexico during the summer half of the year. However, over the barest and flattest surfaces, the Lordsburg-Deming plains and the Jornada del Muerto basin for instance, they appear frequently in the landscape even in winter. Hence one may occasionally see a "snow devil."

Dust devils vary in basal diameter from one to fifty feet, though a few attain a diameter of 150 feet. Their height is of the order of twenty-five to 450 feet, with no consistent ratio between diameter and height. Though stationary dust devils exist, they usually move; the direction of motion is sometimes guided by minor topographic features but more often by gentle local wind. On windless days, and over flat playas, dust devils follow a regular spiral, counterclockwise course.(1) Their rate of horizontal motion varies from five to thirty miles per hour.(2) They may appear any time during the period of summer daylight, with perhaps maximum frequency around noon and in the early part of the afternoon. The passage of a dust devil is marked by the sudden updraft of air which may reach a velocity of up to twenty-eight miles per hour, and which varies sharply in speed and direction. According to DeMastus,(3) the atmospheric conditions for dust devils are as follows. (1) Little or no wind movement. With strong wind, the mechanical mixing of the lower layers of the atmosphere would not allow for the development of a steep (superadiabatic) lapse rate. (2) Surface air temperature must increase during the morning hours at a rate of at least 4.5° F per hour, so that by the early afternoon a shallow, unbalanced atmospheric condition is established. (3) The moisture content of air must remain low so that rapid heating of the lower layers may take place.

DUST STORMS

Widespread and thick drifts of dust affecting the entire state or a large portion of the state are associated with the passage of cyclones, and in particular, cyclones with sharp, cold fronts. Dust storms caused by general cyclonic winds tend to develop gradually, and the life of the typical cyclonic duster is limited to daylight hours. In the words of Warn:

> Wind speeds usually increase to 15 to 20 miles per hour between 8 to 10 a.m. The winds cause low drifting silt and sand. As the winds increase to 20 to 25 miles per hour, a thin, yellow haze of dust is carried up to several hundred feet. By noon the effects of daytime heating are apparent and wind speeds range up to 30 miles per hour....By 3 to 4 p.m. winds may increase to 45 miles per hour, when a dense brownish haze of dust begins to obscure the sky. Dust may be carried to 12,000 feet

(1) Ives, R. L., "Behavior of Dust Devils," Bull. Amer. Met. Soc., Vol. 28, 1947, p. 169

(2) Warn, G. F., "Some Dust Storm Conditions of the Southern High Plains," Bull. Amer. Met. Soc., Vol. 33, 1952, p. 241

(3) DeMastus, H. L., "Pressure Disturbances in the Vicinity of Dust Devils," Bull. Amer. Met. Soc., Vol. 35, 1954, p. 497

or more above the surface with visibility dropping to a range of 3/4 to 2 miles....Cyclonic winds normally diminish by sundown.(4)

For a severe dust storm to occur, a steep rate of surface heating, encouraging atmospheric instability, seems essential. Without the steep vertical temperature gradient, steady winds of twenty-five to forty miles per hour may produce little or no gustiness and, consequently, little or no dust.

Cyclonic dust storms rise and die gradually. In contrast is the sudden approach of a wall of dust along the path of a steep cold front or pre-frontal squall-line. Sharp changes of temperature are associated with such frontal storms. Cold fronts may sweep across the state at all seasons of the year, but they reach maximum frequency (and cause the sharpest temperature changes) in spring and fall. In winter, the air is much less turbulent than in spring and summer. The passage of a cold front in winter, even when accompanied by strong wind, produces little dust, especially if large portions of the state are blanketed with snow, or have recently been moistened by precipitation. In summer, the air is much more turbulent. However, frontal and convectional disturbances are often accompanied by rain, which keeps down the dust. Summer is also the season when vegetation cover is relatively dense. Spring in New Mexico usually marks the climax of a long, dry season. It is also a time when lapse rates are frequently steep, the result of the rapid heating of the dry ground and surface air in contrast with the the layers above which remain cold. Spring, therefore, is the season of dust storms, the most severe of which come with the passage of squall-lines and sharp fronts.

The frequency and severity of dust storms expectedly vary with the spacing and duration of dry spells over a period of decades. The year 1956 was the driest on record in New Mexico. Moreover,it marked the climax of a long, dry phase which may be said to have begun in 1943. The spring months of March and April, particularly, lacked rainfall. For Albuquerque, March of 1956 was the driest on record. For New Mexico, April of that year was the fourth driest since the turn of the century. In eastern New Mexico and adjoining Texas, the combination of dry topsoil and high winds produced in March some of the most severe dust storms of recent years in the region of the Great Plains (Figure 45).(5) In April, 1956, New Mexico was crossed by cold fronts more than a dozen times; they trailed southward from lows that passed to the north of the state,

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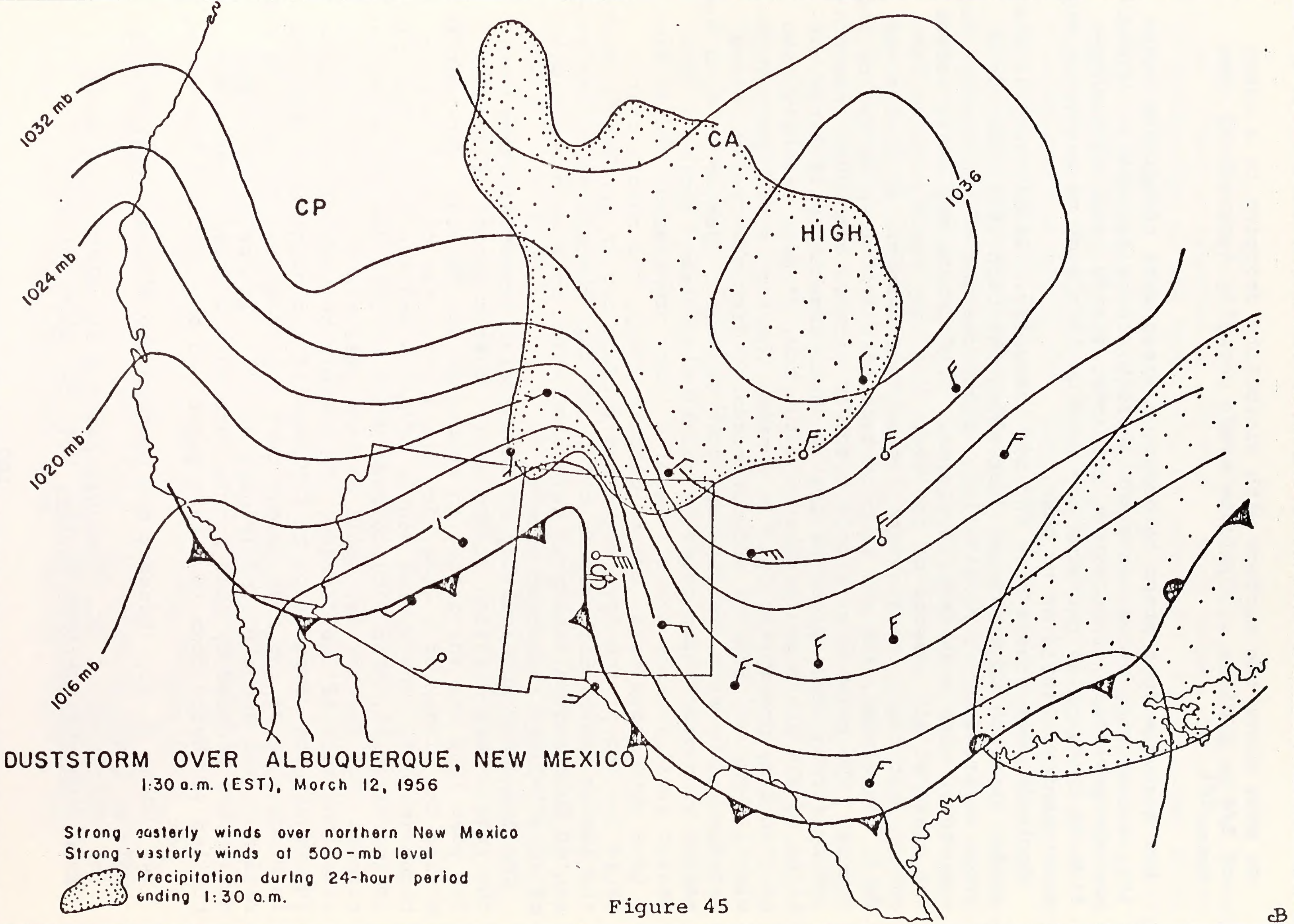
(4) Warn, G. F., "Drought and Dust on the Plains," Weatherwise, Vol. 6, 1953, p. 70

(5) Woffinden, C. M., "The Weather and Circulation of March 1956," Monthly Weather Review, Vol. 84, 1956, p. 115



DUSTSTORM OVER ALBUQUERQUE, NEW MEXICO
1:30 a.m. (EST), March 12, 1956

Strong aasterly winds over northern New Mexico
Strong vasterly winds at 500-mb level
Precipitation during 24-hour period ending 1:30 a.m.

Figure 45

and dust storms rather than precipitation resulted from their passage.

One especially severe dust storm occurred at 2:30 p.m., local time, on April 2, 1956, and brought complete darkness to Midland, Texas (Figure 46). In Roswell, New Mexico, wind speed reached sixty-five miles per hour. The strong winds damaged trees, light structures, and electric lines.(6)

A more recent example of severe dustiness occurred during March 15th and 17th, 1963. There were two storms, each preceding passage of a cold front. Strong, warm winds from the south were characteristic. At Albuquerque, the peak temperature on the 15th was 66° F. It was a very warm day for March in New Mexico. Dust-filled winds averaged thirty to forty miles per hour over most the state, and occasionally reached fifty miles per hour at Albuquerque. On Sandia Crest the velocity reached eighty miles per hour with gusts exceeding 100 miles per hour at times. Roads remained clear although heavy dust clouds reduced visibility and slowed traffic for a short time in the Grants area.(7) The next day (March 16th) was clear and cool following the passage of the cold front. The sky remained clear on the morning of March 17th,but by early afternoon temperature rose sharply; gustiness and wind increased to thirty to forty miles per hour, whipping up dust, particularly in the middle and upper Rio Grande Valley. Meteorologically, the dust storm on March 17th was a repetition of that on the 15th. The synoptic pattern during both occasions combine an upper-level trough with surface cold front and strong, gusty winds.

Statistical information is lacking as to the seasonal distribution, intensity and duration of dust storms for New Mexico as a whole. Von Eschen has compiled data for Albuquerque, of which Table 24 is a summary. The information is based on sixteen years (1945-1960) of hourly weather observation made at the Municipal Airport (Sunport) in Albuquerque. Dust storms are divided into three categories; severe, moderate, and light, defined as follows:

severe: Continuous blowing dust for three hours or more with the visibility restricted to one mile or less at some time during the storm;

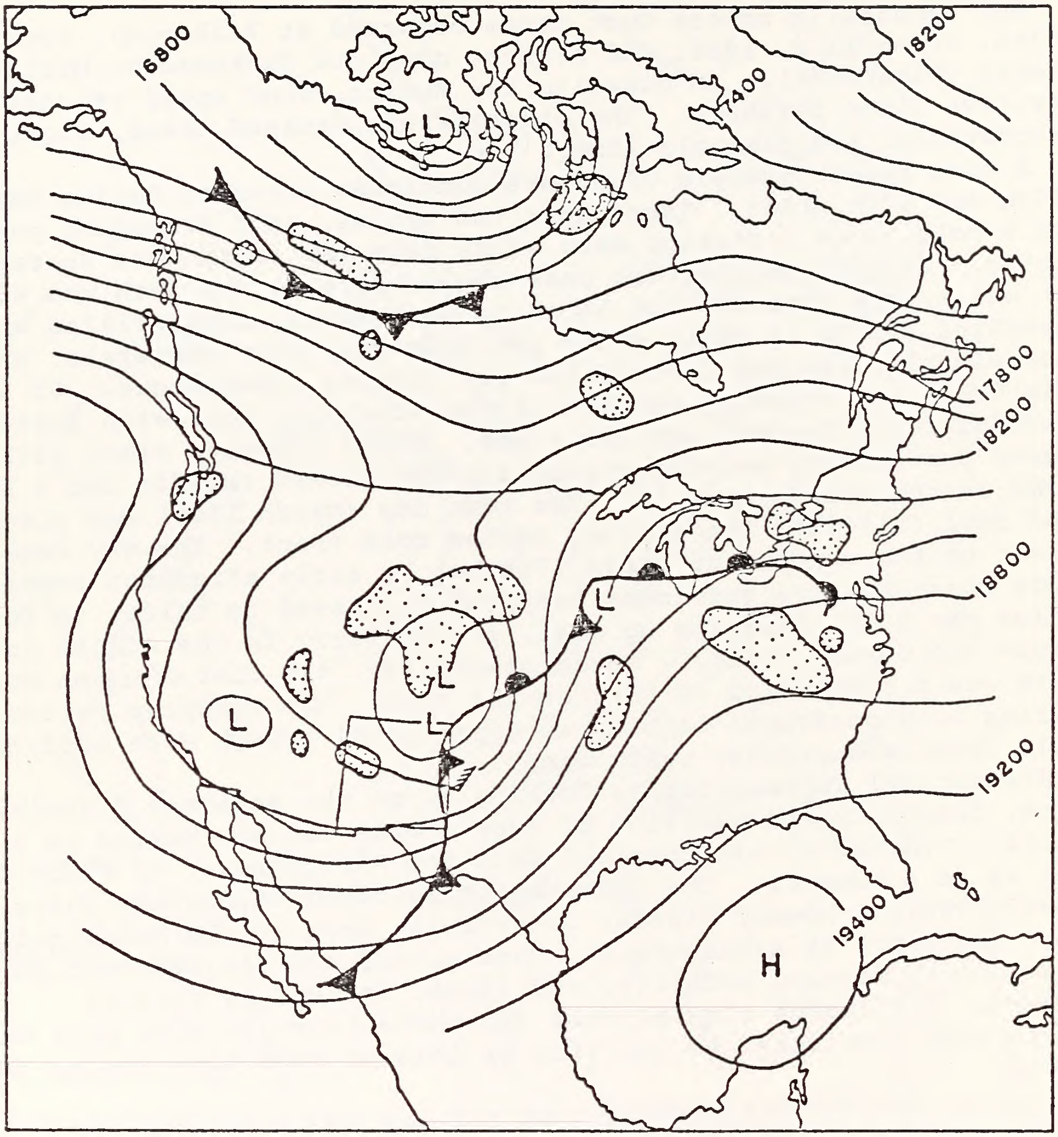
moderate: Continuous blowing dust for two hours or more and visibility four miles or less during the storm (but not qualifying as severe);

light: All other dust storms during which the visibility was restricted to six miles or less (but not qualifying as moderate or severe).

The table supports Von Eschen's description:

(6) Dunn, C. R., "The Weather and Circulation April 1956,"*Monthly Weather Review*, Vol. 84, 1956, p. 153

(7) *Albuquerque Journal*, March 16, 18, 1963



DUSTSTORM OVER EASTERN NEW MEXICO AND WESTERN TEXAS

500-mb surface (contours in feet)	10-11 p.m. (EST)
Surface fronts and rain areas (stippled)	1:30 p.m. (EST) April 2nd, 1956

Figure 46

B

Spring months have the most dust storms, with an average of about five days in April when some blowing dust will occur. Fall and early winter months have the least dust, with September recording some dust on an average of every other year. Although April averages more dust storms than any other month, March storms normally last somewhat longer. September has the least number of dust storms but those in July and August are usually of shorter duration.(8)

Table 24. Dust Storms in Albuquerque* (16-year period 1945-1960)

Month	Total number of days with blowing dust	Storms classified Severe	Moderate	Light
January	14	4	3	7
February	26	7	11	8
March	44	15	12	17
April	75	18	21	36
May	55	2	8	45
June	56	5	6	45
July	38	1	2	35
August	10	0	1	9
September	8	0	2	6
October	15	0	5	10
November	13	1	2	10
December	10	3	3	4
Total	364	56	76	232
Average year	23	3	5	15

* After Von Eschen

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(8) Von Eschen, G. F., Dust Storms in Albuquerque, New Mexico, mimeographed bulletin, 2 pages

CHAPTER V

RAINFALL INTENSITY

Maps or tables showing the amount and distribution of precipitation during the month, season, or year are statistical generalizations. They do not give the actual patterns nor reveal the varying intensities with which the rains fall. The rain accumulated in a month may have fallen gently over periods of many hours, or it may have come in a few short downpours. For example, the total rainfall at Artesia in July, 1911, was 7.76 inches, but 5.5 inches of that amount fell in one day, the 24th.(1)

The amount of rain falling in a short period (twenty-four hours or less) is defined as rainfall intensity. It is an important aspect of rainfall, particularly in a state such as New Mexico where much of the summer rain comes in short, heavy thunderstorms. Very intense precipitation, combined with the flash floods to which it frequently gives rise, may cause serious damage to soil, vegetation, buildings, and property in general. The 2.5 inches of rain that fell on Albuquerque between six and nine o'clock on the evening of August 10, 1963, caused flood damages amounting to two million dollars.(2)

MEASUREMENT OF RAINFALL INTENSITY

At substations sponsored by the Weather Bureau, rainfall is normally measured once every twenty-four hours. But severe summer rainstorms are short-lived, and the twenty-four hour intensity can be very misleading. For example, of the 2.63 inches that fell at the State College on August 29, 1935, 1.06 inches came down in ten minutes, a very high intensity.(3) This storm illustrates another limitation of the once daily measurement of precipitation. The rain started late at night on the 29th and continued into the early hours of the 30th, but in the records two separate twenty-four-hour totals would be given for the one storm. It follows that recording rain gages, providing a continuous record of rainfall throughout the twenty-four-hour period are essential for the proper understanding of rainfall intensity. Unfortunately, the network of recording rain gages is sparse: a density of a little over one per 1,000 square miles for the United States, and only about one per 1,800 square miles for New Mexico.

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(1) Monthly Weather Review, Weather Bureau, Vol. 39, 1911, p. 1067, 1070

(2) Damage to city facilities conservatively estimated at $382,075 by E. O. Betts, City Director of Public Works. However, estimates of damage to city and private property reached as high as two million dollars. Reported in Albuquerque Journal, August 13, 1963

(3) Hardy, E. L., J. C. Overpeck, and C. P. Wilson, "Precipitation and Evaporation in New Mexico," Bull. New Mexico Agricultural Experiment Station, No. 269, 1939, p. 52

Since a summer shower may wet an area of only a few square miles, in addition to improving the statewide network of gages, the establishment of a small number of very dense local networks of self-recording gages would add much to our knowledge of the nature of intense rainfalls. In New Mexico the densest network was established at the Navajo Conservation Experiment Station north of Gallup,where eighty-three recording gages were spaced at intervals of less than one mile apart. Such a concentration of gages makes possible the construction of isohyetal maps of one storm.

SOME CHARACTERISTIC FEATURES

Field observations indicate that in summer showers the highest intensity comes at (or soon after) the commencement of the rain. Lulls may separate a series of intense falls but these seldom exceed twenty minutes in duration.

The area covered by intense storms varies appreciably. The center of high intensity may be no more than eight square miles and the total wetted area some eighty square miles. Nearly twenty-eight square miles, centered on western Las Cruces, received exceptionally heavy rain on August 29-30, 1935 (Figure 15).(4)

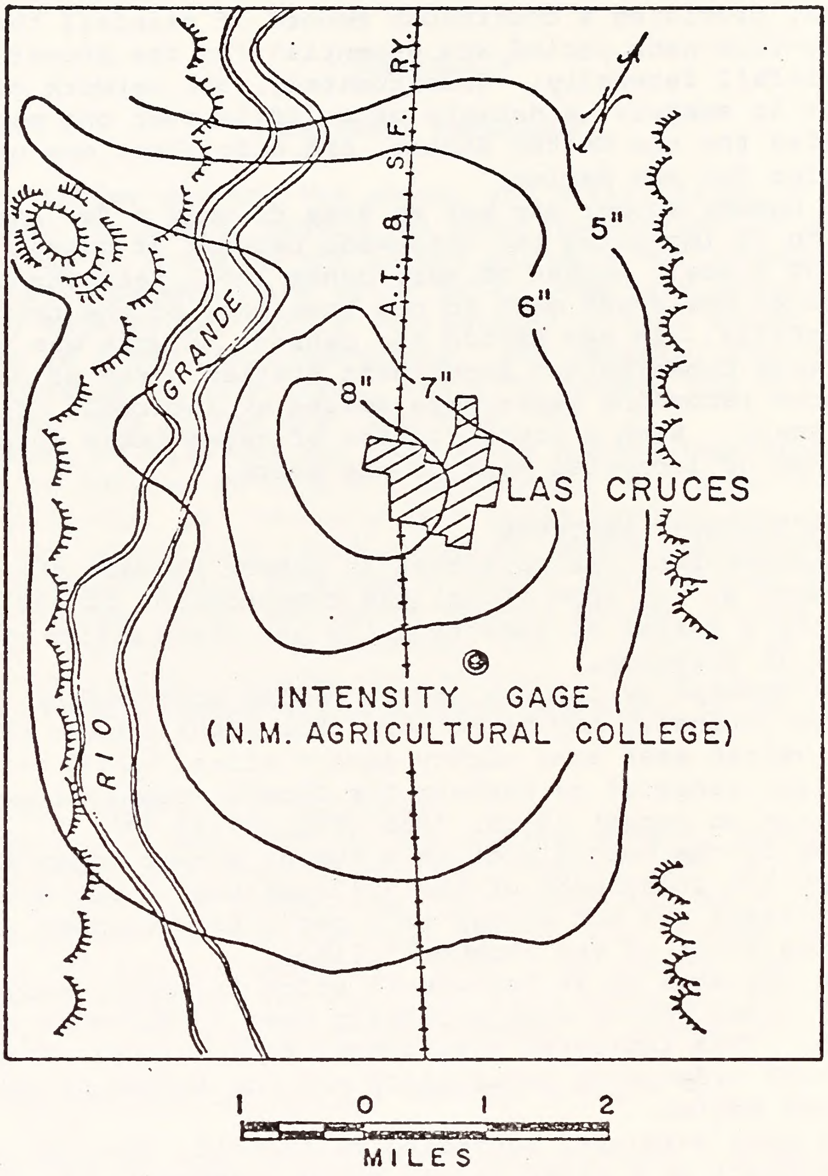
The shape of the wetted area in a summer shower appears to be influenced by the topography of the drainage basin, but with most local storms there are not enough rain gages to determine at all accurately the shape of the isohyetal lines.

Although the area of an individual storm is small, many such storms may occur nearly simultaneously over a region as large as New Mexico. This indicates that summer conventional storms are associated with widespread instability and the influx of moist air over a large region.

There is some evidence, according to Leopold, that the area covered by rainfall in a given summer storm increases with the total precipitation in the storm center. (5) It seems established, at least, that storms occurring in the Pecos basin cover larger areas

(4) Leopold, L. B., "Areal Extent of Intense Rainfalls, New Mexico and Arizona," Trans. Amer. Geophys. Union, Nov., 1942, Pt. II, pp. 558-559

(5) See next page



RAIN OF AUGUST 29-30, 1935

Figure 15

than storms in any other section of the state, and also that any given amount of storm rainfall occurs there more frequently than in any other section of the state.

In contrast to local cloudbursts are spring or summer rainfalls that may last over a period of several days, as, for instance, the storms of May 20-28, 1941, in southeastern New Mexico (Figure 16). Such storms cover much larger areas than local convective showers. They have pockets of high intensity in them, but, measured over the time span of an hour, these centers are not as intense as the local cloudbursts. Such storms are probably associated with frontal activity.

SEASONAL AND AREAL DISTRIBUTION

Intense rains are characteristic of the summer and early fall, while few are recorded in New Mexico from November to March. Highland areas may show large totals in the winter season, but the precipitation is not particularly intense.

High rain intensities are more common in the eastern portion of the state where heaviest falls occur between early July and mid-August, with a second peak in mid-September. This areal distribution results from the fact that the Gulf of Mexico is the primary source of moist unstable air. Hence storms in the Pecos River basin appear more frequently and last longer than in other parts of the state. Conversely, the northwestern part of the state, farthest removed from the source of moist air, derives less of its rainfall from these summer storms than any other part of New Mexico.

MAXIMUM RECORDED TWENTY-FOUR-HOUR INTENSITIES

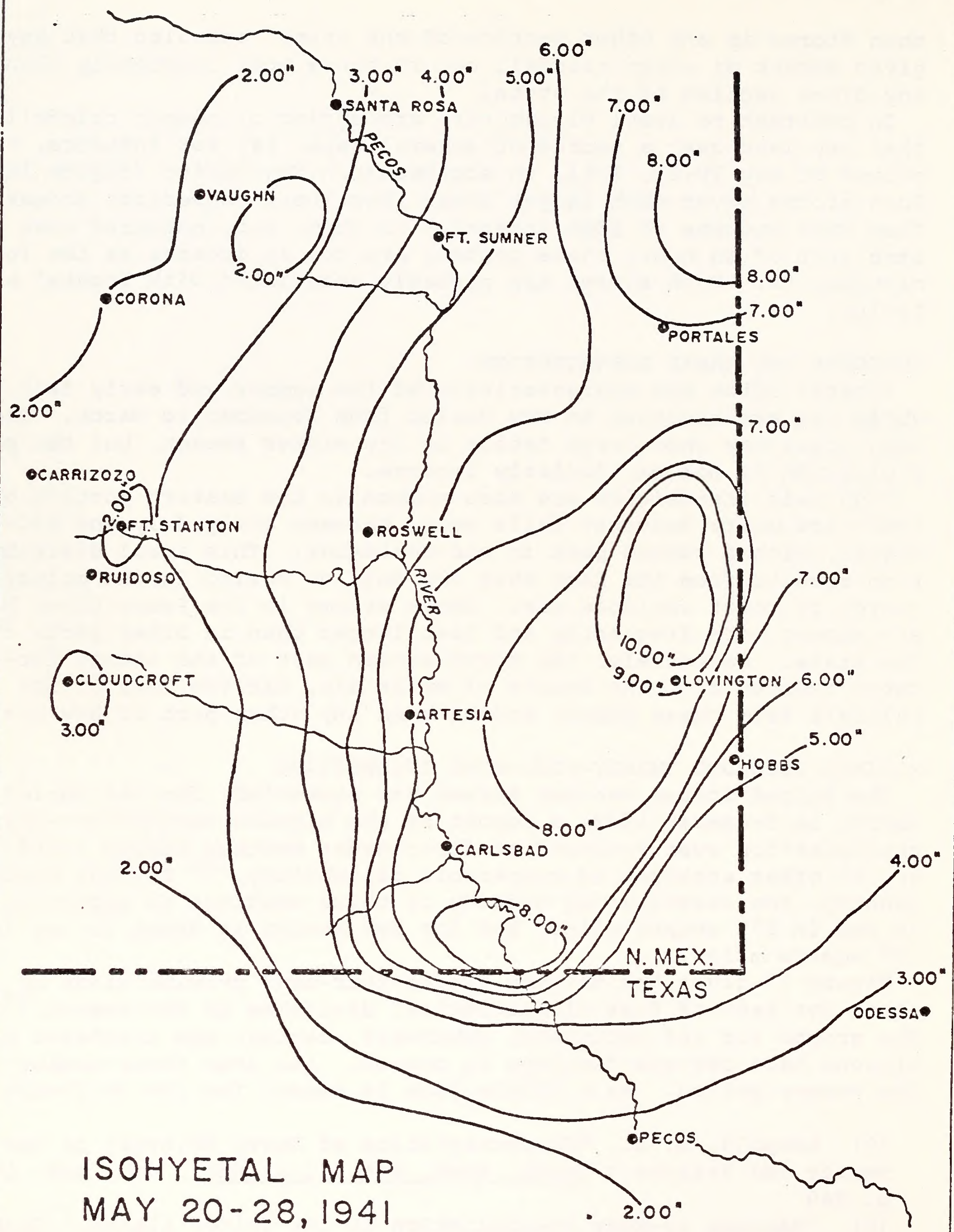
The United States Weather Bureau has assembled, for the period ending in December 1949, a report of the highest twenty-four-hour precipitation ever recorded at first-order Weather Bureau stations and at other stations of comparable reliability.(6) For the whole country, the distribution density of these stations is approximately one in 275 square miles, but for New Mexico it drops to one in 520 square miles.

Figure 17 gives the maximum twenty-four-hour precipitation by month for each of five climatological divisions of New Mexico.(7) The graphs for the northwest, southwest, center, and southeast divisions have certain features in common. All show their maxima in the summer period, as a single peak in August for the northwest,

(5) Leopold, L. B., "Characteristics of Heavy Rainfall in New Mexico and Arizona," Trans. Amer. Soc. Civil Eng., Vol. 109, 1944, p. 840

(6) "Maximum 24-Hour Precipitation in the United States," Technical Paper, No. 16, Weather Bureau, U.S. Department of Commerce

(7) Based on data in Technical Paper, No. 16, Table 74, pp. 185-191



ISOHYETAL MAP
MAY 20-28, 1941
PECOS BASIN

After Weather Bureau Office, Albuquerque, N. M.

Figure 16

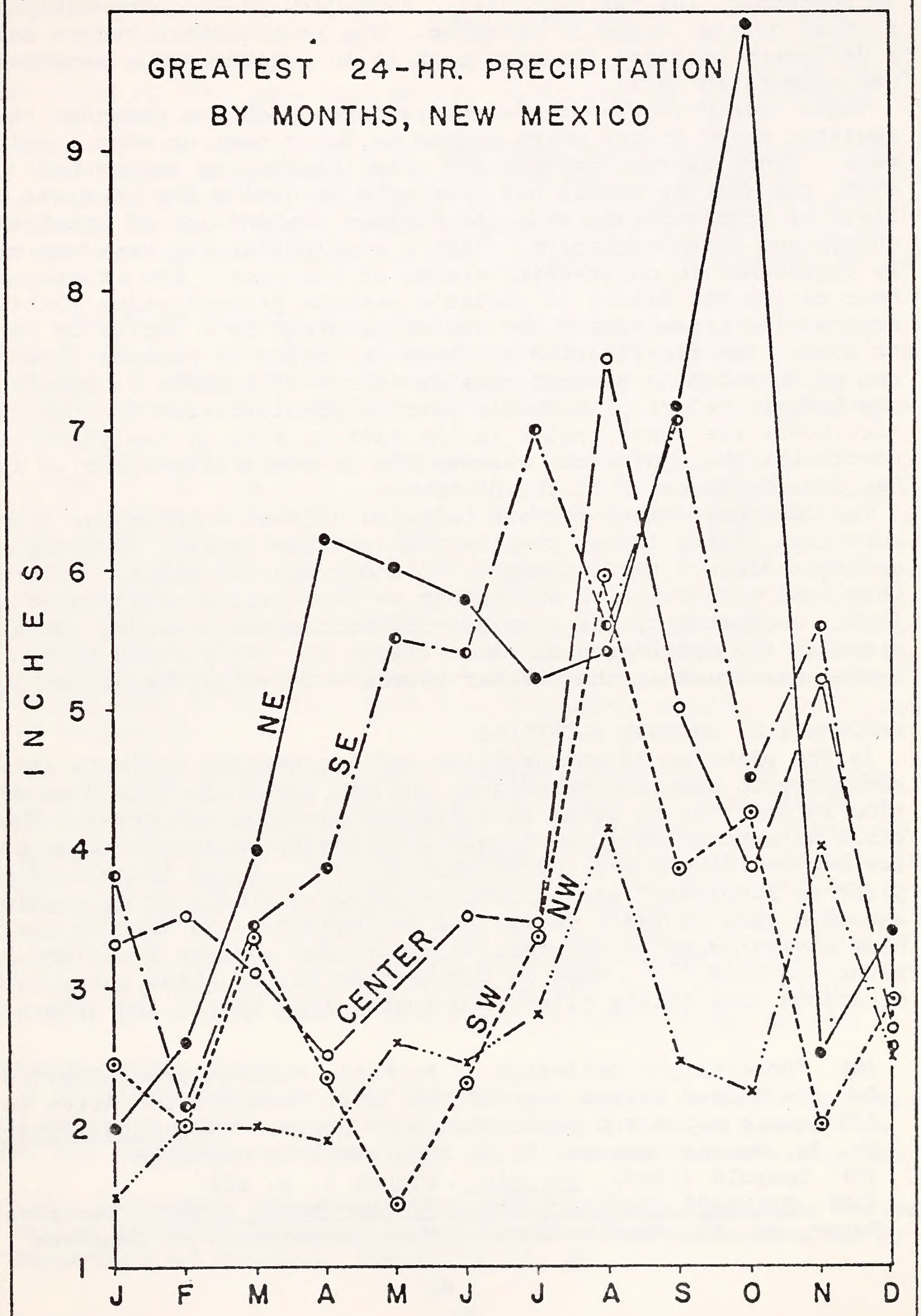

GREATEST 24-HR. PRECIPITATION
BY MONTHS, NEW MEXICO
INCHES
1
2
3
4
5
6
7
8
9
J
F
M
A
M
J
J
A
S
O
N
D
NE
SE
NW
CENTER
SW

Figure 17

JB

southwest, and center, and as two peaks one in July and the other in September, for the southeast. Secondary peaks, presumably of frontal origin, occur in November. The northeastern sector follows a different pattern; the main peak is in October and a secondary one appears in April.

These twenty-four-hour maxima are largely chance records; they register major storms which happen to occur near or over a rain gage. Other storms, perhaps far more intense, go unrecorded. However, the Weather Bureau has been able to derive the physical upper limit of precipitation from the optimum combination of moisture charge and storm mechanism. Such a combination may have been closely approached in outstanding storms of the past. For a twenty-four-hour period the values of probable maximum precipitation within ten square mile areas exceed the maxima recorded by a factor of three to four. The distribution of these rainfalls of maximum intensity can be expected on general considerations of sources of moisture; the highest values of probable maximum precipitation for twenty-four hours are concentrated in the eastern part of the state, in particular the southeast, whereas the lowest values occur in the San Juan-Chaco basin of the northwest.

The interpretation of these computed values, which range from more than thirty inches to less than sixteen inches, requires a full understanding of their theoretical and pragmatic basis. Otherwise, they seem much too high and appear to bear little relation to the limits suggested by the standard climatological records. Detailed steps in the derivation of these values for the western United States are found in the Weather Bureau's Technical Paper, No. 38.(8)

FREQUENCY OF INTENSE RAINFALLS

In the planning of conservation and engineering projects it is necessary to know how frequently one may expect certain precipitation intensities to recur in different parts of the state. The first attempt to estimate Rainfall-Intensity-Duration-Frequencies for New Mexico was made by Yardell in 1935. Later Leopold (9) prepared an isopluvial map of twenty-four-rain likely to be equaled or exceeded once in fifty years, and subsequently the Weather Bureau drew several maps of rainfall intensity for various durations and return periods.(10) Maps in the Weather Bureau Atlas cover storm durations from thirty minutes to twenty-four hours, and return

(8) "Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian for Areas to 400 Square Miles and Durations to 24 Hours," Technical Paper, No. 38, Weather Bureau, U. S. Department of Commerce

(9) Leopold (1944), op. cit., Figure 5, p. 865

(10) Rainfall Frequency Atlas of the United States, Technical Paper, No. 40, Weather Bureau, U. S. Department of Commerce

periods of one to 100 years. (Return period means the interval of years within which the magnitude of the rainfall event will be equaled or exceeded once, on the average.) The maps in the Atlas published in 1961 show less detail than those in Technical Paper No. 28, published in 1956.

Figure 18 is reproduced from Technical Paper No. 28,as an example of what might be achieved by a detailed survey. It shows values of one-hour rainfall (in hundredths of an inch) that may be equaled or exceeded, on the average, once in every two years.(11) The map brings out two features of the pattern of intense rainfall in New Mexico:

a) Rainfall intensity decreases westward, away from the source of moist air. In fact, rainfalls of high intensity are closely related to high annual (or seasonal) totals. The southeastern plains receive more intense rains than does the dry northwestern plateau.

b) Topography exerts an influence. The most intense falls predicated at the two-year frequency are in the Sacramento Mountains (1.5 inches), and falls of 1.2 inches or more might be expected over much of the eastern plains. Intensities decrease in the Rio Grande trough and in the lee of high mountains. The southwestern part of the state shows two areas with values exceeding 1.1 inches. In the north, the Jemez Mountains stand out as an isolated center enclosed by the isopleth of 1.0 inch. The northwest, expectedly, has the least value, 0.5 inch or less. No other published maps of Rainfall-Intensity-Frequency compare with Figure 18 in detail.

The Rainfall Frequency Atlas (Technical Paper No. 40) extends the return periods to fifty and 100 years. Maps for this length of time can only be very generalized. It is instructive to compare the twenty-four-hour fifty-year frequency map prepared by Leopold (1944) and an equivalent map in the Atlas. The discrepancies between them bespeak the uncertainty in the estimation of such values. Leopold's map (reproduced in Figure 19) puts much of the eastern Plains in the six-inch plus category,whereas on the Weather Bureau map the five-inch isohyet only just enters the state. Leopold's map also shows more detail in the western part of New Mexico.

SEASONAL PROBABILITY

In Technical Paper No. 40, the Weather Bureau attempts to present the seasonal probability of intense rainfall for periods of one, six, and twenty-four hours. The study, however, covers only the

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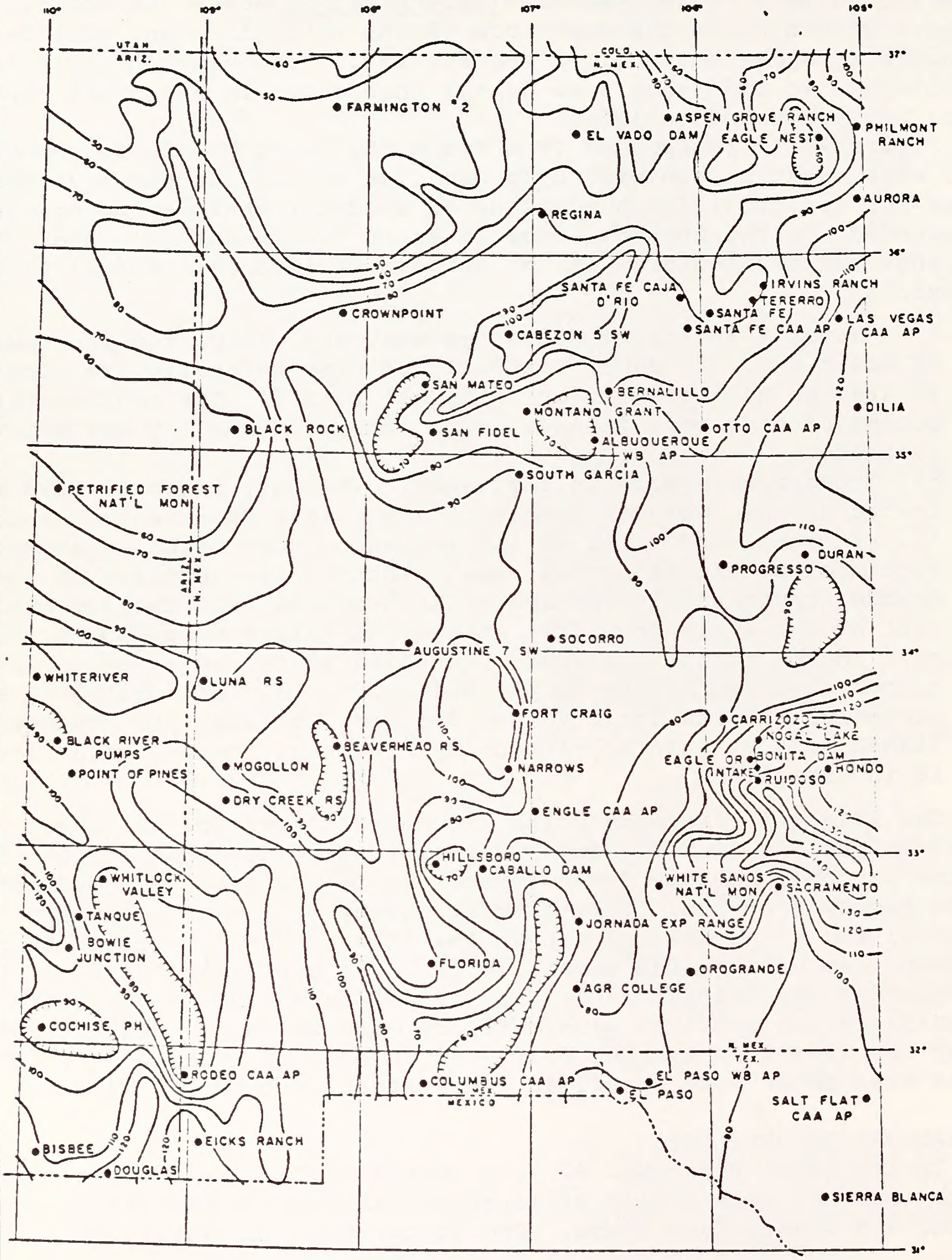
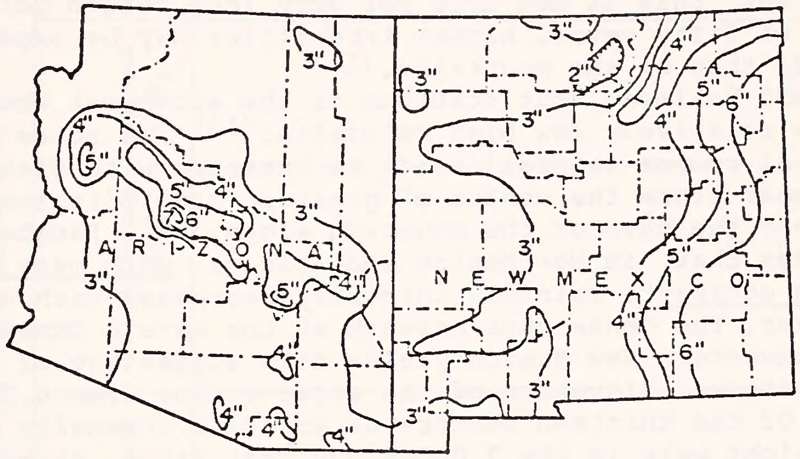
(11) "Rainfall Intensities for Local Drainage Design in Western United States," Technical Paper, No. 28, Weather Bureau, U. S. Department of Commerce, Figure 11, p. 16



2-YEAR 1-HOUR RAINFALL

ISOPLUVIALS IN HUNDREDTHS OF AN INCH (AFTER WEATHER BUREAU)

Figure 18



ISOPLUVIAL MAP OF ARIZONA AND NEW MEXICO
(24-Hr. Rain Equaled or Exceeded Once in 50 Years)
After Leopold

Figure 19

eastern third of New Mexico. On the southeastern Plains, May is the most probable month for intense one-hour falls. September and October form a secondary peak. Intense six-hour falls are more likely in May and September than in any other month for return periods of up to four years. For longer periods a third peak appears in July. Intense falls within twenty-four hours appear to be concentrated in two seasons, April-May and September-October, for all return periods up to twenty years.

The probabilities for very heavy falls (intensities that may be expected within long periods) are quite small. For instance, in the lower Pecos Valley the probability that a location in any particular year will receive in May, within one hour, rainfall equal or exceeding 1.5 inches is less than five percent. For two inches in an hour, the amount that may be expected at least once in twenty-five years, the probability that it will come during May of any particular year drops to about one percent.

RAINFALL INTENSITY AND ALTITUDE

The relation between altitude and rainfall intensity has not yet been clearly resolved for Arizona and New Mexico. One source of difficulty is again the lack of rain gages at high altitudes.

Langbein, in his study of summer rains in Arizona, concludes that, on the average, rainfall intensities are greatest in the range of altitudes between 3,000 feet and 4,000 feet. His data show also a notable decline in expected intensities at high altitudes. In addition, it would seem that whereas for return periods of ten years and less, higher intensities may be expected at 7,000 feet than at 1,000 feet, this is not true for very long return periods. Within a span of fifty years, higher intensities may be expected over the lowlands than on the mountains.(12)

Leopold believes that stations in the southwest above 7,500 feet receive relatively few high rainfalls.(13) He notes that whereas the total summer rainfall tends to increase with elevation, in any one summer storm the center of greatest precipitation usually occurs near the base of the mountain slope.(14) Langbein similarly concludes that, in New Mexico and Arizona, with mean annual precipitation constant, rainfall intensity decreases with altitude.(15)

However, the dense gage network at the Navajo Experiment Station in northwestern New Mexico yields data suggestive of contrary interpretation. Elevation of the gages varies from 6,200 to 8,200 feet. Of the thirteen centers of greatest intensity recorded in 1941, eight were in the 7,000-8,000 feet range, three below and two above; and six out of thirteen maximum intensities were measured above 7,500 feet.(16)

(12) Langbein, W. B., discussion in Leopold (1944, op. cit.), p. 881
(13) Leopold (1944), op. cit., p. 859
(14) Leopold (1944), op. cit., p. 840
(15) Langbein, W. B., in Leopold (1944, op. cit.), p. 883
(16) Harrold, L. L., discussion in Leopold (1944, op. cit.), pp. 868-870

APPENDIX A-7

Chemical Analyses of Selected Constituents in Samples of Water and Brine in Eastern Eddy County, New Mexico

ANALYSES BY AMAX CHEMICAL CORPORATION

SOURCE	LOCATION, SECTION, TOWNSHIP, RANGE.	DATE OF COLLECTION	Concentrations (parts per million)						
			Calcium Ca	Magnesium Mg	Potassium K	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total Dissolved Solids
Well (Charlie Walters)	Sec.26,T.18S.,R30E	2-26-51	88	44	2			65	595
		1-04-55	105	47	1			98	598
		3-11-58	96	49	3			96	653
		1-27-60	103	58	2			102	658
		10-18-63	121	73	2			99	716
		5-19-65	127	46	3			106	624
		11-01-67	115	50	3			106	792
		11-05-69	126	48	2			105	588
		11-03-71	151	62	3			142	720
		11-14-73	137	54	2	210	227	115	794
		5-08-74	159	61	3	232	239	147	868

Chemical Analyses of Selected Constituents in Samples of Water and Brine in Eastern Eddy County, New Mexico

ANALYSES BY AMAX CHEMICAL CORPORATION

SOURCE	LOCATION, SECTION, TOWNSHIP, RANGE.	DATE OF COLLECTION	Concentrations (parts per million)						
			Calcium Ca	Magnesium Mg	Potassium K	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total Dissolved Solids
Well 13 (Benson, West of North Lake)	Sec.23,T.19S.,R29E	2-28-51	617	50	6			46	2,572
		1-04-55	653	65	5			46	2,488
		3-11-58	595	75	4			25	2,540
		1-27-60	637	68	4			46	2,632
		10-18-63	674	31	4			35	2,650
		5-19-65	657	39	6			24	2,538
		11-01-67	645	45	4			35	2,466
		11-05-69	591	35	7			43	2,240
		11-04-71	641	45	6			32	2,424
		5-17-73	657	47	7	239	1,468	46	2,396

Chemical Analyses of Selected Constituents in Samples of Water and Brine in Eastern Eddy County, New Mexico

ANALYSES BY AMAX CHEMICAL CORPORATION

SOURCE	LOCATION, SECTION, TOWNSHIP, RANGE.	DATE OF COLLECTION	Concentrations (parts per million)						
			Calcium Ca	Magnesium Mg	Potassium K	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total Dissolved Solids
		5-08-74	631	41	7	199	1,542	39	2,428
Well 12 Benson North Lake (1966)	Sec.13,T.19S.,R29E	2-28-51	615	95	20			221	2,965
		1-04-55	625	94	0			213	3,128
		12-12-66	612	92	13			252	3,014
		11-04-70	633	93	14			261	3,132
		5-03-72	625	95	16	193	1,800	261	3,044
		5-08-74	625	96	12	148	1,812	280	3,188
Well 9 TX Ranch Headquarters	Sec.25,T.19S.,R30E	2-27-51	654	52	6			144	2,567
		1-04-55	672	68	6			142	3,052
		6-03-57	653	54	6			125	2,817

Chemical Analyses of Selected Constituents in Samples of Water and Brine in Eastern Eddy County, New Mexico

ANALYSES BY AMAX CHEMICAL CORPORATION

SOURCE	LOCATION, SECTION, TOWNSHIP, RANGE.	DATE OF COLLECTION	Concentrations (parts per million)						
			Calcium Ca	Magnesium Mg	Potassium K	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total Dissolved Solids
		1-27-60	623	76	5			124	2,804
		11-10-65	700	21	4			106	2,746
		5-01-68	658	38	5			103	2,628
		11-04-70	657	46	5			121	2,638
		5-03-72	665	43	5	237	1,540	101	2,596
Hackberry Well	Sec.25,T.19S.,R30E	5-30-72	103	44	34		20	433	642
		5-17-73	112	49	41	53	13	493	750
		11-14-73	109	46	39	36	10	491	816
Hackberry Lake	Sec.25,T.19S.,R30E	6-16-66						172,000	
		5-06-70	34	14	60			160	538
		11-04-70	34	10	56			163	482

Chemical Analyses of Selected Constituents in Samples of Water and Brine in Eastern Eddy County, New Mexico

ANALYSES BY AMAX CHEMICAL CORPORATION

			Concentrations (parts per million)						
SOURCE	LOCATION, SECTION, TOWNSHIP, RANGE.	DATE OF COLLECTION	Calcium Ca	Magnesium Mg	Potassium K	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total Dissolved Solids
Well 4 Lusk South (old)	Sec,28,T.19S.,R30E	2-27-51	515	305	16			60	3,555
		1-04-55	449	264	20			69	3,180
		5-21-58	569	195	17			69	3,304
		5-21-64	249	124	11			72	1,776
		5-01-68	468	262	28			80	3,016
		5-03-72	315	196	16	195	1,380	83	2,118
		5-08-74	424	240	17	204	1,824	103	2,896
Clayton Lake	Sec.3,T.20S.,R30E	11-04-70	1,159	305	117			1,181	4,108
		5-06-70	667	45	69			1,303	7,290
		5-05-71	1,846	654	189			5,311	12,380

Chemical Analyses of Selected Constituents in Samples of Water and Brine in Eastern Eddy County, New Mexico

ANALYSES BY AMAX CHEMICAL CORPORATION

SOURCE	LOCATION, SECTION, TOWNSHIP, RANGE.	DATE OF COLLECTION	Concentrations (parts per million)						
			Calcium Ca	Magnesium Mg	Potassium K	Bicarbonate HCO_3	Sulfate SO_4	Chloride Cl	Total Dissolved Solids
		5-03-72	3,203	1,042	107	82	2,470	10,396	19,024
		5-17-72	1,870	841	179	188	2,904	6,842	14,244
		5-08-74	3,816	1,280	112	84	2,420	13,126	22,760

APPENDIX A-8

Soil Groupings - Potash Area

Group I Shallow Over Caliche

Arvana - Lea (AW)

Cacique (CA)

Kimbrough (KP, KN)

Kimbrough - Stegall (KT)

Karro (KU)

Maljamar - Palomas (MF)

Mixed Alluvial land (MU)

Potter - Simona complex (PS)

Rock land (RO)

Simona (SA, SE, SG)

Simona - Bippus complex (SM)

Simona - Wink (SN)

Stegall - Slaughter (SS)

Tonuco (TC, TE, TF, TN)

Tonuco - Berino (TO)

Upton (UG)

These soils have formed in a thin water laid mantle of sands of mixed origin or in old alluvium derived from calcareous sedimentary rocks. They are generally located on a generally level to gently sloping landscape. They are moderately dark colored noncalcareous to calcareous with moderately coarse textures and are characteristically shallow over indurated caliche. These soils are well to excessively drained.

The surface texture of these soils range from fine sandy loam, through loam to gravelly loam. They vary in color from brown to dark grayish brown and may be 2 to 7 inches in depth. The subsoil ranges from 2 to 17 inches in depth, and varies in texture from sandy loam to gravelly loam. Fractured, platy, indurated caliche is typically found at 9 to 19 inches depth. The soils having more loam in their profile are uneroded or slightly eroded, whereas, the more sandy soils are subject to severe wind erosion if the vegetative cover is depleted. Permeability of these soils is generally moderate with water holding capacity being low. Runoff is slow to medium, with most rainfall being taken into the soil. These soils tend to be droughty because of their inability to retain water in the profile. Organic matter content is moderate and soils may be productive if favorable precipitation is available.

A typical profile of this grouping is as follows:

A11-0 to 3 inches, dark grayish brown (10 YR 4/2) loam, very dark grayish brown (10 YR 3/2) when moist; weak, thin, platy structure to moderate, fine granular; hard when dry, friable when moist, slightly sticky and plastic when wet; noncalcareous; neutral; abrupt, smooth boundary.

A12-3 to 7 inches, dark brown (7.5 YR 4/3) loam, dark brown (7.5 YR 3/2) when moist; weak, medium to fine, subangular blocky structure; very hard when dry; friable when moist, sticky and slightly plastic when wet; slightly calcareous; mildly alkaline; abrupt, smooth boundary.

C1ca-7 to 9 inches, brown (7.5 YR 5/3) loam, dark brown (7.5 YR 3/3) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; strongly calcareous; mildly alkaline; abrupt, smooth boundary.

C2cam-9 inches, white fractured, platy, indurated caliche. Large fragments of indurated caliche are common in all profiles.

Vegetation found and/or associated with Group I is as follows:

Black grama

Blue grama

Side oats grama

Hairy grama

Tobosa

Broom snakeweed

Sand dropseed

Three-Awn

Little blue stem

Sand muhly

Burro grass

Creosote bush

Tar bush

Sand sagebrush

Javelina

Yucca

Mesquite

APPENDIX

Soil Groupings - Potash Area

Group II - Shallow Over Gypsiferous Rock

Cottonwood - Reeves (CR)

Gypsum land (GA)

Gypsum land - Cottonwood complex (GC)

Cypsum land - Reeves complex (GR)

Reagan - Upton (RE)

Reeves - Gypsum land complex (RG)

Reeves - Reagan (RM)

Russler (RS)

Reeves - Cottonwood (RT)

Stony Rough Broken Land (SR)

Soils of this grouping have developed in old alluvium derived from sedimentary rocks. They are level to gently undulating and occur on the higher positions of the landscape. They consist of well-drained, calcareous, light colored soils that are characteristically shallow to moderately deep over beds of gypsiferous earths or rocks.

These soils typically have a surface layer of light gray to light brownish-gray loam. They are underlain by gypsiferous material at a depth of 9 to 45 inches. Where the gypsum is deeper, a clay loam subsoil may be present. The gypsiferous material ranges from white, chalky earths to hard, light-colored, crystalline gypsum rock. Fine to coarse gypsum crystals are common on the surfaces of barren areas.

The surface layer is moderately permeable and the underlying gypsiferous material is slowly permeable. Surface runoff ranges from slow to very rapid, and the water holding capacity is very low. The soil material is well drained, but very droughty and saline. The organic-matter content is low and fertility is considered moderate. These soils are susceptible to erosion and most areas are slightly to moderately eroded. The rooting system is restricted by the gypsiferous material which is close to the surface.

A typical profile of this grouping is as follows:

A11-0 to 1 inch, light gray (10 YR 7/2) loam, brown (10 YR 5/3) when moist; strong, very thin to thin, platy structure; soft when dry, very friable when moist, nonsticky when wet; discontinuous horizon; spots of organic matter as much as 1/4 inch thick between A11 and A12 horizons; slightly to strongly calcareous; neutral to mildly alkaline; abrupt, smooth boundary.

C1-5 to 9 inches, light brownish-gray (10 YR 6/2) loam, dark brown (10 YR 4/3) when moist; massive; soft when dry, friable when moist, nonsticky when wet; common prominent lime mycelis; slightly to strongly calcareous; neutral to mildly alkaline; abrupt, wavy boundary.

C2cs-9 to 36 inches, white (10 YR 8/2) gypsum, very pale brown (10 YR 7/3) when moist; massive; alternately soft and very hard when dry, nonsticky when wet; contains semi-indurated lenses; horizon covered by discontinuous silica shell 1/16 to 1/4 inch thick; strongly calcareous; mildly alkaline; gradual, wavy boundary.

C3cs-36 to 60 inches, very pale brown (10 YR 7/4) gypsum, brownish-yellow (10 YR 6/6) when moist, intermingled with white (10 YR 8/2) gypsum, light gray (10 YR 7/2) when moist; massive; soft when dry, nonsticky when wet; strongly calcareous; moderately alkaline. The gypsiferous material ranges from soft, loamy material to hard rock.

Typical vegetation found and/or associated with Group II is as follows:

Gyp grama
Black grama
Blue grama
Side oats grama
Alkali sacaton
Coldenia
American tarbush

Soaptree yucca

Broom snakeweed

Vine mesquite

Burro grass

Mesquite

APPENDIX

Soil Groupings - Potash Area

Group III - Dune Sand, Deep-Hummocky

Active Dune land (AD)

Berino (BA)

Berino complex (BB)

Berino - Dune land complex (BD)

Berino - Cacique (BH)

Berino - Pajarito complex (BP)

Karro (KA)

Kermit - Palomas (KD)

Kermit - Berino (KM)

Pajarito (PA)

Pajarito - Dune land complex (PD)

Pyote (PT)

Pyote - Maljamar (PU)

Pyote soils and Dune land (PY)

This grouping consists of deep, noncalcareous, yellowish-red to red, sandy soils that developed in wind worked material of mixed origin overlying alluvial, sandy, calcareous sediments. Hummocky, dune-like typography is characteristic of this grouping with the soils occurring as gently sloping, undulating and/or hummocky dunes.

The surface layer may range from yellowish-red fine sand to reddish-brown loamy fine sand from 6 to 36 inches thick. The subsoil ranges from yellowish-red fine sandy loam to dark red sandy clay loam which is 30 to 42 inches thick. The substratum to a depth of 60 inches or more is pink light sandy clay loam that has a high lime content.

Overall permeability of these soils is moderately rapid, with permeability being rapid in the surface layer and moderately slow in the subsoil. Most rainfall goes into the soil, with runoff being slow and water intake rapid. The surface layer has a low water holding capacity. The depth to a distinct layer of lime accumulation ranges from 36 to 60 inches. Roots penetrate to a depth of 60 inches or to the layer of lime accumulation.

These soils are subject to continuing wind and water erosion. If vegetative cover is seriously depleted, the erosion hazard is severe. Where erosion is active in and around the dunes, the surface layer has been removed, with little or no vegetation growing in that area.

A typical profile of this grouping is as follows:

Al-0 to 17 inches, yellowish-red 5 YR 4/6) fine sand, yellowish-red (5 YR 3/6) when moist; single grain; loose when dry or moist, nonsticky and nonplastic when wet; noncalcareous; neutral; abrupt, smooth boundary.

B21-17 to 23 inches, yellowish-red (5 YR 4/6) fine sandy loam, dark red (2.5 YR 3/6) when moist; weak, coarse, prismatic structure; very hard when dry, friable when moist, slightly sticky and nonplastic when wet; thin, continuous clay films on all ped surfaces; noncalcareous; neutral; clear, smooth boundary.

B22t - 23 to 36 inches, red (2.5 YR 4/6) sandy clay loam, dark red (2.5 YR 3/6) when moist; moderate, coarse, prismatic structure breaking to weak, medium and coarse, subangular blocky; extremely hard when dry, firm when moist, sticky and plastic when wet; thin continuous clay films on all ped surfaces; noncalcareous; neutral; clear, wavy boundary.

B3t-36 to 50 inches, dark-red (2.5 YR 3/6) light sandy clay loam, dark red (2.5 YR 2/6) when moist; weak, coarse, prismatic structure; extremely hard when dry, firm when moist, sticky and plastic when wet; thin, continuous clay films on all ped surfaces; few distinct splotches of lime; noncalcareous; neutral to mildly alkaline; abrupt, wavy boundary.

Cca-50 to 58 inches, pink (5 YR 7/3) clay loam, light reddish brown (2.5 YR 6/4) when moist; massive; extremely hard when dry, firm when moist, sticky and plastic when wet; strongly calcareous; moderately alkaline.

Typical vegetation found and/or associated with Group III are as follows:

Bush muhly

Plains bristlegrass

Blue grama

Harvard oak

Tobosa

Sand dropseed

Three-Awn

Broom snakeweed

Yucca

Sand bluestem

Sand sage

Mesquite

Shin oak

APPENDIX

Soil Groupings - Potash Area

Group IV Loamy Soils - Deep

Anthony - (AA)

Berino - Cacique (BE, BF)

Dev - Pima complex (DP)

Harkey (HK)

Largo (LA)

Largo - Stony land complex (LN)

Largo - Pajarito complex (LP)

Likes (LS)

Mobeetie (MO)

Portales (PC)

Portales and Gomez (PG)

Pima (PM)

Reagan (RA)

Wink (WK)

This unit consists of deep, well-drained reddish brown, calcareous gently sloping soils that developed in alluvium derived from upland sedimentary materials and/or wind and water deposited sediments. They generally occur on upland alluvial fans in the study area.

Typically, the surface layer is brown to reddish brown fine sandy loam to loam. This layer is generally about 6 inches in depth. The subsoil is reddish brown to yellowish red stratified loam, light silty clay loam and clay loam about 14 to 40 inches thick. The substratum to a depth of 60 inches is loam and/or weak red silty and clayey shale. These soils are calcareous throughout.

Permeability of these soils is moderate with runoff being slow to medium. Water intake is moderate and water holding capacity is medium to high. The organic matter content is low and fertility is moderate. Roots may penetrate to a depth of 20 to 60 inches, or to the strong lime zone. These soils have been slightly eroded by water. Deep V-shaped gullies are common in the drainage ways. Erosion can be moderate to severe hazard. The soil is generally fertile and there are little or no root restrictions. A typical profile is as follows:

A1-0 to 4 inches, reddish brown (5 YR 5/3) loam, dark reddish brown (5 YR 3/3) when moist; weak, medium, platy structure in the uppermost 1 inch grading to weak, medium and fine, subangular blocky; soft when dry, friable when moist, slightly sticky and plastic when wet; many fine pores; plentiful fine and medium roots; common faint seams of lime and few soft concretions; strongly calcareous; mildly alkaline; abrupt boundary.

AC-4 to 20 inches, reddish brown (5 YR 5/3) silt loam, reddish brown (5 YR 4/3) when moist; weak, coarse, prismatic structure breaking to weak, coarse, subangular blocky; slightly hard when dry, friable when moist, sticky and plastic when wet; many fine and medium pores; many very fine and fine roots; common faint seams of lime and few soft concretions; few limestone pebbles; strongly calcareous; mildly alkaline; gradual boundary.

C1-20 to 47 inches, reddish brown (5 YR 5/4) silt loam, reddish brown (5 YR 4/4) when moist; weak, coarse, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; many fine and medium pores; few very fine roots; strongly calcareous; mildly alkaline; abrupt, wavy boundary.

IIC2-47 to 65 inches +, reddish brown (5 RY 5/4) loam, reddish brown (5 YR 4/4) when moist; massive, hard when dry, friable when moist, sticky and plastic when wet; about 5% gravel; strongly calcareous; mildly alkaline.

The thickness of the A1 horizon ranges from 3 to 6 inches. The C horizon contains thin strata of fine sandy loam and sandy clay loam, mixed with coarse fragments of caliche, sandstone, limestone, shale and siltstone. In some profiles, gravel is scattered throughout and makes up about 5% of the soil mass.

Typical vegetation found and/or associated with Group IV is as follows:

Black grama

Side oats grama

Blue grama

Little bluestem

Burrograss

Tobasso

Bush muhly

Sand muhly

Sand dropseed

Javelina

Three-Awn

Sand sagebrush

Broom snakeweed

Mesquite

Vine mesquite

Alkali socaton

Buffalo grass

Yucca

Creosote bush

APPENDIX

Soil Groupings - Potash Area

Group V - Deep, - Over Soft Caliche

Midessa (MM)

Midessa and Wink (MN)

Mobeetie - Potter (MW)

Wink (WF)

Jal (JA)

This soil grouping has formed in chalky stream or lake sediments, or as strongly calcareous, wind and water deposited sandy sediments in shallow basins. They are located on nearly level to gently sloping positions. The soils are well-drained, with a loam to clay loam subsoil that is typically high in lime.

The surface layer may range from a pale brown to brown sandy loam or fine sand to dark grayish brown loam which is underlain by pale brown to brown loam or clay loam. The depth of the surface layer ranges from 2 to 15 inches. The subsoil is a brown to pale brown loam to clay loam that varies from 11 to 18 inches in depth. The substratum to a depth of 60 inches ranges from a white sandy loam or light gray clay loam with a high lime content to a soft white caliche. The soil is calcareous throughout.

This soil is moderately permeable. Runoff is slow with water intake being moderate to rapid. Water holding capacity is low to moderate. Roots penetrate to a depth of 20 to 39 inches to the strong lime zone or the soft caliche layer. Soil blowing is a moderate to severe hazard.

A typical profile of this unit is found below:

A11-0 to 2 inches, dark grayish brown (10 YR 4/2) loam, very dark grayish brown (10 YR 3/2) when moist; weak, thin platy, fine, granular, structure; soft friable when moist, slightly sticky and plastic when wet; few fine roots; mildly alkaline (pH 7.7), slightly calcareous; abrupt boundary, 2 to 4 inches thick.

A12-2 to 4 inches, dark grayish brown (10 YR 4/2) loam, very dark grayish brown (10 YR 3/2) when moist; moderate, fine subangular blocky structure; slightly hard, friable when moist, slightly sticky and plastic when wet; few fine roots; few worm casts; mildly alkaline (pH 7.8), slightly calcareous; abrupt boundary, 2 to 3 inches thick.

B21-4 to 12 inches, grayish brown (10 YR 5/2) clay loam, brown (10 YR 5/3) when moist; moderate, medium, subangular blocky structure; hard, firm when moist, sticky and plastic when wet; few fine roots; many fine tubular pores; few worm casts; many fine calcium carbonate concretions; moderately alkaline (pH 8.2), strongly calcareous; clear boundary, 7 to 20 inches thick.

B22-12 to 22 inches, pale brown (10 YR 6/3) clay loam, brown (10 YR 5/3) when moist; moderate, medium, subangular blocky structure; slightly hard, very friable when moist, sticky and plastic when wet; few fine roots; many soft and hard, fine calcium carbonate concretions; moderately alkaline (pH 8.4), strongly calcareous; gradual boundary, 9 to 12 inches thick.

Cca-22 to 60 inches, light gray (10 YR 7/2), soft caliche consisting of clay loam, gray (10 YR 6/1) when moist; moderate, fine subangular blocky structure; hard, firm when moist; sticky and plastic when wet; about 35% chalky or silty soils mixed with soft calcium carbonate, decreasing in lime content below a depth of 48 inches; moderately alkaline (pH 8.4), strongly calcareous.

Typical vegetation found and/or associated with Group V soils are as follows:

Black grama
Blue grama
Side oats grama
Tobosa
Three-Awn
Tarbush
Sand sagebrush

Mesquite

Broom snakeweed

APPENDIX

Soil Groupings - Potash Area

Group VI - Playas

Playas - (PB)

Playas are barren, flat, generally dry, undrained basins. Some contain shallow water for short periods at infrequent intervals. Commonly, these areas are salty. They consist mainly of silty and clayey, water laid sediments. They are subject to periodic overflow and are barren of vegetation other than a few annual forbs.

APPENDIX A-9

ENGINEERING INTERPRETATIONS OF SOILS IN THE POTASH STUDY AREA

Soil Groups and Soil Series	Depth to Bedrock, Hard Caliche, or Gypsum	Suitability As A Source of		Soil Features Effecting					
		Topsoil	Roadfill	Dikes and Levees	Ponds Reservoir Area	Ponds Embankment	Leveling	Foundations	Pipelines
Group I:									
Kimbrough	2 to 18 inches	Poor; gravelly; indurated caliche at 6" - 18"	Fair; depth to 6 " - 18"	Indurated caliche at a depth of ½ foot to 1½ feet.					
Simona	10 to 24 inches	Poor; fertility low, shallow over indurated caliche	Poor; limited fine, sandy loam material	Indurated caliche ½ foot to 1½ feet.			Cuts limited by caliche	Erosion hazard; indurated caliche at ½ to 1½ feet	Shallow over indurated caliche
Upton	2 to 20 inches	Poor; indurated caliche at a depth of 6" - 18"	Unsuitable; limited material fine grained	Indurated caliche at a depth of ½ foot to 1½ feet.				Low shrink-swell potential	
Group II:									
Cottonwood	Soft to hard gypsum below a depth of 9 inches	Poor; low fertility	Fair; low strength, shear very shallow	Gypsiferous materials	Soluble gypsum	Soluble gypsum	Gypsum within a depth of 1 foot	Soluble gypsum	Gypsum, highly corrosive
Gypsum Land	Soft to hard gypsum at a depth of 0 to 10 inches	Poor; little or no soil	Poor, gypsiferous, material	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Poor shear strength and bearing capacity	Special treatment needed for gypsum salts

APPENDIX A-9 cont.

ENGINEERING INTERPRETATIONS OF SOILS IN THE POTASH STUDY AREA

		Suitability As A Source of			Soil Features Effecting				
					Ponds				
Soil Groups and Soil Series	Depth to Bedrock, Hard Caliche, or Gypsum	Topsoil	Roadfill	Dikes and Levees	Reservoir Area	Embankment	Leveling	Foundations	Pipelines
Reeves	Soft to hard gypsum at a depth of 10 to 36 inches	Poor; low fertility, saline	Poor;	Gypsiferous material at a depth of 20 to 36 inches	Gypsum at a depth of 1½ to 2½ feet	Gypsiferous substratum	Limitation on depths of cuts	Poor to fair bearing capacity and shear strength; moderate shrink swell potential	Special treatment for salts, (corrosival)
Group III;									
Active Duneland	More than 60 inches	Poor, erodible low fertility	Good, if soil binder used	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Good suitability if soil is contained	Deep, loose sand; blowouts and drifting sands
Berino	More than 60 inches	Poor	Poor, to fair	Sandiness of surface material necessitates mixing with subsoil material	Susceptible to seepage; sandy; surface	Piping; moderate porous	Soft caliche at a depth of 50 (+) inches; highly susceptible to wind erosion	Good bearing capacity	Features favorable
Kermit	More than 60 inches	Poor, drifting sand	Good, if soil binder is used	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Good suitability if soil is confined	Subject to blowouts

ENGINEERING INTERPRETATIONS OF SOILS IN THE POTASH STUDY AREA

Soil Groups and Soil Series	Depth to Bedrock, Hard Caliche, or Gypsum	Suitability As A Source of		Soil Features Effecting					
		Topsoil	Roadfill	Dikes and Levees	Ponds		Leveling	Foundations	Pipelines
					Reservoir Area	Embankment			
Group IV:									
Largo	More than 60 inches	Poor to fair, moderately slow, intake rate erodible	Poor	Unstable level grade necessary	Unstable; good for core material	Unstable; good for core material	Overflow phase is susceptible to pereodic flooding	Fair to poor bering capacity and shear strength low to high shrink-swell potential	Features favorable
Dev	More than 60 inches	Poor, gravel and cobblestones, intermixed with soil material	Fair, careful selection of site required	Features favorable	Gravel and cobbelstone mixed with soil material	Gravel and cobbelstone mixed with soil material	Not Applicable	Poor suitability; susceptible to periodic flooding	Periodic flooding, shifting stream channels
Reagan	More than 60 inches	Fair if fertilized	Fair	Feature favorable	Gypsum or soft saliche below a depth of 40 inches in places	Gypsum or soft caliche below a depth of 40 inches in places	Features favorable	Fair bearing capacity and shear strength low to high shrink-swell potential	Gypsum salts below a depth of 40 inches in places Special treatment needed

ENGINEERING INTERPRETATIONS OF SOILS IN THE POTASH STUDY AREA

Soil Groups and Soil Series	Depth to Bedrock, Hard Caliche, or Gypsum	Suitability As A Source of		Soil Features Effecting					
					Ponds				
		Topsoil	Roadfill	Dikes and Levees	Reservoir Area	Embankment	Leveling	Foundations	Pipelines
Group V :									
Midessa	Soft Caliche at 36 inches	Fair, moderate fertility	Poor	Moderate shrink-swell potential	Soft caliche at a depth of 2 to 3 feet requires compaction	Poor stability, piping hazard	Cuts limited by soft caliche at a depth of 2 to 3 feet	Moderate shrink-swell potential	High lime content, corrosive
Jal	Soft caliche at 18 to 42 inches	Poor, low fertility, high lime content	Fair	Piping hazard severe erosion hazard	Moderate permeability, high, lime content	Piping hazard poor compaction	Severe erosion hazard	Low shrink-swell potential	Moderately corrosive, soft caliche at 12 inches depth
Wink	More than 60 inches	Poor, low fertility	Good to Fair	Severe erosion hazard, piping hazard	High lime content, severe erosion hazard moderately rapid permeability	High lime content	Severe hazard of soil blowing	Low shrink swell potential	Corrosive, severe hazard of soil blowing
Group VI:									
Playas	No Interpretation		Variable, - No Interpretations						

Appendix A-10

Chemical Analyses of Surface Soils in Relation to Distance from Refineries

Lab No.	Sample No.	pH	EC	Ca	Mg	Na	K	SAR
				meq/1				
695	I-1 0-3"	6.91	11.09	4.32	18.94	5.85	67.45	1.72
696	1-1 3"-14"	8.01	9.80	4.10	17.69	15.62	48.26	4.73
697	I-1 14"-22"	7.90	8.31	2.49	12.88	10.92	43.74	3.94
698	1-2 0-3"	7.27	6.81	1.59	4.88	13.88	32.32	7.72
699	1-2 3"-13"	7.86	17.50	17.00	29.29	13.79	77.30	2.87
700	I-3 0-3"	7.78	7.94	3.39	5.40	13.72	29.41	6.54
701	I-3 3"-8"	7.69	12.10	3.98	7.58	21.16	33.72	7.35
702	I-4 0-5"	7.80	1.54	.32	1.31	2.55	7.97	2.47
703	I-4 5"-34"	7.80	1.04	.15	.15	7.16	2.14	18.49
704	I-4 34"-60"	7.72	.85	1.74	.42	5.32	.37	5.12
705	I-5 0-4"	7.87	3.90	1.89	8.17	2.76	19.52	1.23
706	I-5 4"-18"	8.42	3.80	2.75	6.26	3.09	17.14	1.46
707	I-5 33"-60"	8.27	2.09	.17	.71	3.09	11.62	4.66
708	I-6 0-3"	7.20	2.44	1.67	6.34	.66	9.99	.33
709	I-6 3"-16"	7.49	.41	.19	.09	.62	2.27	1.66
710	I-6 30"-36"	7.69	2.22	1.56	3.00	2.82	10.92	1.87
711	I-7 0-4"	7.59	1.59	.54	1.39	.58	9.40	.59
712	I-7 4"-13"	7.76	1.39	.64	1.21	1.21	7.17	1.26
713	I-7 36"-60"	6.89	.94	1.27	.43	2.28	3.46	2.47
714	I-8 0-3"	8.02	2.41	1.42	1.89	1.81	14.88	1.41
715	I-8 3"-13"	7.74	2.55	2.58	2.02	4.07	9.95	2.68
716	M-1 0-3"	7.77	.45	1.90	.40	.65	.85	.61
717	M-1 3"-12"	7.76	.38	1.35	.09	.79	.27	.93
718	M-1 28"-60"	8.08	.38	1.05	.11	2.01	.03	2.64
719	M-2 0-3"	7.81	1.27	2.41	.73	3.14	4.04	2.51
720	M-2 3"-12"	7.72	1.07	.98	.16	2.39	5.38	3.17
721	M-2 36"-44"	8.08	.50	.24	.04	2.61	1.31	6.98
722	K-1 0-3"	7.58	2.60	1.02	.26	6.64	12.17	8.30
723	K-1 3"-12"	8.08	1.51	.75	.08	3.55	6.47	5.51
724	K-2 0-3"	7.34	1.31	.39	.15	3.30	8.09	6.35
725	K-2 3"-14"	7.60	1.23	2.03	.39	2.89	4.30	2.63
726	K-3 0-4"	6.58	.58	.36	.05	1.38	3.31	3.05
727	K-3 4"-14"	7.17	.69	1.02	.24	.79	2.27	1.00
728	K-3 14"-22"	7.30	.41	1.49	.25	.83	.12	.89
729	K-4 0-3"	8.10	9.97	1.62	.66	13.06	69.81	12.23
730	K-4 3"-13"	8.12	10.94	2.31	.49	10.10	142.49	8.54
731	K-5 0-3"	8.26	2.73	.54	.09	3.94	17.59	7.02
732	K-5 3"-13"	7.76	5.61	11.60	.74	9.84	28.97	3.96
733	K-6 0-3"	8.01	4.19	.55	.09	6.45	28.54	11.40
734	K-6 3"-12"	7.97	5.13	1.50	.31	9.29	34.05	9.77
735	K-7 0-4"	8.66	1.20	.16	.04	2.32	7.15	7.34
736	K-7 4"-12"	7.97	1.39	3.42	.50	2.61	5.12	1.86
737	K-7 12"-22"	8.02	.63	1.91	.43	2.67	.13	2.47
738	K-8 0-3"	7.86	.90	.18	.07	1.89	5.90	5.35
739	K-8 3"-16"	7.94	1.50	1.71	.20	1.73	6.44	1.77
740	K-8 36"-42"	8.02	.29	.55	.10	.68	.09	1.19
741	N-1 30"-40"	7.85	42.90	27.70	31.73	130.23	301.31	23.69
742	N-1 4"-23"	8.37	18.50	2.38	1.61	17.02	149.07	12.05
743	N-1 0-4"	8.89	1.86	.26	.08	3.37	12.98	8.17
744	N-2 0-4"	8.62	1.78	.27	.10	2.32	11.60	5.39
745	N-2 4"-18"	8.96	1.94	.13	.09	7.25	12.80	21.86
746	N-2 30"-42"	8.64	2.05	.50	.31	7.19	11.12	11.30

Continued on next page

Lab No.	Sample No.	% Sand	% Silt	% Clay	Texture
695	I-1 0-3"	90.0	3.6	6.4	Sand
696	I-1 3"-14"	92.0	1.6	6.4	Sand
697	1-1 14"-22"	88.8	6.4	4.8	Sand
698	1-2 0-3"	91.6	2.0	6.4	Sand
699	I-2 3"-13"	89.2	2.0	8.8	Sand
700	I-3 0-3"	82.0	10.8	7.2	Loamy Sand
701	1-3 3"-8"	77.2	18.0	4.8	Loamy Sand
702	I-4 0-5"	96.0	1.2	2.8	Sand
703	1-4 5"-34"	89.2	4.4	6.4	Sand
704	1-4 34"-60"	80.0	7.6	12.4	Sandy Loam
705	1-5 0-4"	91.2	4.4	4.4	Sand
706	1-5 4"-18"	92.0	4.8	3.2	Sand
707	I-5 33"-60"	85.2	4.0	10.8	Loamy Sand
708	I-6 0-3"	92.0	2.8	5.2	Sand
709	I-6 3"-16"	91.2	2.4	6.4	Sand
710	I-6 30"-36"	90.8	2.4	6.8	Sand
711	1-7 0-4"	94.4	2.8	2.8	Sand
712	I-7 4"-13"	89.2	4.0	6.8	Sand
713	I-7 36"-60"	85.2	2.0	12.8	Loamy Sand
714	1-8 0-3"	88.0	6.8	5.2	Sand
715	1-8 3"-13"	85.2	6.0	8.8	Loamy Sand
716	M-1 0-3"	82.0	7.2	10.8	Loamy Sand
717	M-1 3"-12"	77.2	10.0	12.8	Saody Loam
718	M-1 28"-60"	76.4	6.8	16.8	Sandy Loam
719	M-2 0-3"	86.8	8.0	5.2	Loamy Sand
720	M-2 3"-12"	89.2	6.0	4.8	Sand
721	M-2 36"-44"	87.2	4.0	8.8	Loamy Sand
722	K-1 0-3"	85.2	8.0	6.8	Loamy Sand
723	K-1 3"-12"	83.2	8.0	8.8	Loamy Sand
724	K-2 0-3"	91.6	5.2	3.2	Sand
725	L-2 3"-14"	89.2	4.0	6.8	Sand
726	K-3 0-4"	93.6	.8	5.6	Sand
727	K-3 4"-14"	90.8	4.4	4.8	Sand
728	K-3 14"-22"	87.6	.8	11.6	Loamy Sand
729	K-4 0-3"	77.2	14.0	8.8	Sandy Loam
730	K-4 3"-13"	70.4	14.8	14.8	Sandy Loam
731	K-5 0-3"	75.2	20.0	4.8	Loamy Sand
732	K-5 3"-13"	73.6	14.8	11.6	Sandy Loam
733	K-6 0-3"	67.2	21.6	11.2	Sandy Loam
734	K-6 3"-12"	65.6	21.2	13.2	Sandy Loam
735	K-7 0-4"	93.2	2.0	4.8	Sand
736	K-7 4"-12"	87.6	2.8	9.6	Loamy Sand
737	K-7 12"-22"	82.8	4.0	13.2	Sandy Loam
738	K-8 0-3"	93.6	2.8	3.6	Sand
739	K-8 3"-16"	84.8	4.0	11.2	Loamy Sand
740	K-8 36"-42"	85.6	2.8	11.6	Loamy Sand
741	N-1 30"-40"	44.8	28.0	27.2	Clay Loam
742	N-1 4"-23"	57.6	12.8	29.6	Sandy Clay Loam
743	N-1 0-4"	66.8	16.4	16.8	Sandy Loam
744	N-2 0-4"	61.2	18.8	20.0	Sandy Loam
745	N-2 4"-18"	61.2	18.0	20.8	Sandy Clay Loam
746	N-2 30"-42"	56.0	21.2	22.8	Sandy Clay Loam
747	N-3 0-4"	64.8	24.4	10.8	Sandy Loam

Continued on next page

Lab No.	Sample No.	pH	EC	Ca	Mg	Na	K	SAR
				meq/1				
747	N-3 0-4"	8.81	1.32	.14	.05	2.67	7.45	8.66
748	N-3 4"-21"	8.47	2.15	.41	.18	6.82	13.32	12.56
749	N-4 0-4"	7.27	63.50	143.53	62.49	151.45	187.30	14.92
750	N-4 4"-13"	7.48	31.50	55.23	74.78	84.33	89.53	10.46
751	N-4 16"-23"	7.74	26.40	9.13	198.82	65.38	15.82	6.41
752	N-5 0-3"	8.54	6.81	11.19	7.60	17.32	14.74	5.65
753	N-5 3"-12"	7.96	5.54	11.66	2.71	19.49	15.82	7.27
754	N-6 0-3"	8.01	2.92	3.77	.73	8.02	10.93	5.35
755	N-6 3"-16"	7.92	1.38	5.24	.80	2.74	1.83	1.58
756	N-7 0-3"	7.49	80.40	20.93	5.30	793.52	165.18	219.12
757	N-7 3"-14"	7.68	46.80	73.65	2.19	632.94	23.21	102.78
758	N-7 24"-30"	7.26	40.80	183.41	7.64	207.05	.21	21.18
759	N-8 0-4"	7.77	2.07	5.39	.27	10.96	1.50	6.52
760	N-8 4"-16"	7.86	2.56	13.36	.31	3.74	.14	1.43
761	0-1 0-3"	8.39	26.20	23.33	52.19	30.79	224.98	5.01
762	D-1 3"-14"	8.13	18.10	17.46	25.14	12.99	162.26	2.81
763	D-2 0-4"	8.39	2.44	1.52	1.14	.98	17.73	.85
764	D-2 4"-12"	8.01	3.01	3.18	.47	4.35	19.45	3.22
765	D-2 28"-34"	7.90	2.61	14.65	2.93	7.08	1.19	2.39
766	D-3 0-4"	8.64	30.70	19.42	119.86	76.22	291.75	9.13
767	0-3 4:-13"	8.36	25.80	35.31	78.08	8.73	222.22	1.16
768	0-4 0-3"	8.22	11.55	11.58	19.11	3.12	87.95	.80
769	0-4 3"-17"	8.03	7.88	18.13	13.30	2.94	53.68	.74
770	D-5 0-4"	7.65	2.67	3.44	1.60	1.62	16.43	1.02
771	D-5 4"-20"	7.67	1.52	7.27	1.16	1.25	3.85	.61
772	D-5 34"-42"	7.81	1.26	10.50	1.31	1.43	.44	.59
773	D-6 0-4"	7.01	.41	.12	.12	.32	2.73	.92
774	0-6 4"-12"	6.97	1.17	1.24	.62	1.74	10.44	1.80
775	D-6 32"-38"	7.60	.39	2.65	.58	.51	.09	.40
776	D-7 0-3"	7.07	5.93	8.30	3.05	6.12	35.81	2.57
777	D-7 3"-15"	7.08	9.66	78.28	17.05	17.98	1.45	2.60
778	D-8 0-3"	7.82	.73	.37	.34	.38	4.91	.64
779	D-8 3"-12"	7.17	.70	.54	.35	.46	4.19	.69
780	0-8 28"-34"	7.24	.95	1.96	.29	.34	5.42	.32
781	0-9 0-4"	7.99	.39	1.56	.24	.44	.98	.46
782	0-9 4"-15"	8.44	.69	.97	.26	2.01	2.63	2.56
783	D-9 30"-34"	8.54	.45	.61	.11	1.81	.72	3.02
784	P-1 0-4"	7.62	16.90	8.63	4.28	48.60	74.92	19.13
785	P-1 4"-24"	7.72	5.97	31.07	.96	3.61	33.03	.90
786	P-1 24"-29"	7.89	7.29	20.86	.58	.45	47.74	.14
787	P-2 0-3"	7.96	4.57	2.47	.25	8.02	26.35	6.88
768	P-2 3"-14"	8.28	2.32	.35	.09	3.82	13.78	8.14
789	P-2 14"-24"	7.74	5.91	20.05	.43	5.41	32.70	1.69
790	P-3 0-3"	7.22	95.90	39.76	136.36	327.47	725.55	34.89
791	P-3 14"-18"	7.84	12.40	12.22	7.63	25.39	58.12	8.06
792	P-4 0-3"	7.77	5.69	13.28	.70	7.63	28.37	2.89
793	P-4 3"-12"	7.67	4.75	36.28	1.24	5.39	14.83	1.24
794	P-5 0-6"	7.53	10.43	58.29	1.36	16.83	41.36	3.08
795	P-6 0-3"	7.56	3.63	50.08	1.37	8.65	38.76	1.71
796	P-6 3"-13"	7.98	8.43	22.85	.91	5.08	64.63	1.47
797	P-6 34"-38"	7.62	7.29	42.11	3.04	14.47	15.74	3.05
798	P-7 0-3"	7.70	20.70	18.60	2.61	32.31	134.26	9.92

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Lab No.	Sample No.	% Sand	% Silt	% Clay	Texture
748	N-3 4"-21"	62.0	27.2	10.8	Sandy Loam
749	N-4 0-4"	61.2	34.2	4.6	Sandy Loam
750	N-4 4"-13"	54.0	42.8	3.2	Sandy Loam
751	N-5 16"-23"	55.2	41.4	3.4	Sandy Loam
752	N-5 0-3"	59.2	18.2	22.6	Sandy Clay Loam
753	N-5 3"-12"	50.8	27.2	22.0	Sandy Clay Loam
754	N-6 0-3"	52.0	32.0	16.0	Sandy Loam
755	N-6 3"-16"	46.2	29.4	24.4	Loam
756	N-7 0-3"	45.4	21.8	32.8	Sandy Clay Loam
757	N-7 3"-14"	30.4	27.0	42.6	Clay
758	N-7 24"-30"	28.0	67.2	4.8	Silt Loam
759	N-8 0-4"	71.6	17.6	10.8	Sandy Loam
760	N-8 4"-16"	64.8	19.2	16.0	Sandy Loam
761	D-1 0-3"	60.0	28.0	12.0	Sandy Loam
762	0-1 3"-14"	56.0	30.6	13.4	Sandy Loam
763	D-2 0-4"	83.8	6.0	10.2	Loamy Sand
764	0-2 4"-12"	80.2	7.8	12.0	Sandy Loam
765	D-2 28"-34"	84.2	6.4	9.4	Loamy Sand
766	D-3 0-4"	68.8	16.8	14.4	Sandy Loam
767	d-3 4"-13"	66.2	20.4	13.4	Sandy Loam
768	D-4 0-3"	72.8	13.8	13.4	Sandy Loam
769	D-4 3"-17"	80.2	1.2	18.6	Sandy Loam
770	D-5 0-4"	79.6	6.8	13.6	Sandy Loam
771	D-5 4"-20"	76.0	7.4	16.6	Sandy Loam
772	D-5 34"-42"	73.4	7.0	19.6	Sandy Loam
773	D-6 0-4"	91.0	3.4	5.6	Sand
774	D-6 4"-12"	87.4	2.0	10.6	Loamy Sand
775	D-6 32"-38"	73.2	2.4	24.4	Sandy Clay Loam
776	D-7 0-3"	78.4	4.0	17.6	Sandy Loam
777	D-7 3"-15"	76.2	7.4	16.4	Sandy Loam
778	0-8 0-3"	95.6	.8	3.6	Sand
779	D-8 3"-12"	96.2	.2	3.6	Sand
780	D-8 28"-34"	96.4	.6	3.0	Sand
781	0-9 0-4"	92.2	3.2	4.6	Sand
782	0-9 4"-15"	93.4	2.0	4.6	Sand
783	0-9 30"-34"	93.6	1.0	5.4	Sand
784	P-1 0-4"	85.4	8.0	6.6	Loamy Sand
785	P-1 4"-24"	72.4	12.2	15.4	Sandy Loam
786	P-1 24"-29"	63.4	34.2	2.4	Sandy Loam
787	P-2 0-3"	90.2	5.2	4.6	Sand
788	P-2 3"-14"	83.4	5.8	10.8	Loamy Sand
789	P-2 14"-24"	77.2	10.2	12.6	Sandy Loam
790	P-3 0-3"	30.6	61.8	7.6	Silt Loam
791	P-3 14"-18"	44.0	53.6	2.4	Silt Loam
792	P-4 0-3"	39.4	37.8	22.8	Loam
793	P-4 3"-12"	50.0	28.6	21.4	Loam
794	P-5 0-6"	84.4	9.6	6.0	Loamy Sand
795	P-6 0-3"	29.2	57.4	13.4	Silt Loam
796	P-6 3"-13"	31.6	42.0	26.4	Loam
797	P-6 34"-38"	35.2	36.2	28.6	Clay Loam
798	P-7 0-3"	44.6	36.8	18.6	Loam
799	P-7 3"-11"	39.0	38.2	22.8	Loam
800	P-7 24"-29"	32.4	44.8	22.8	Loam

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Appendix A-10
Continued

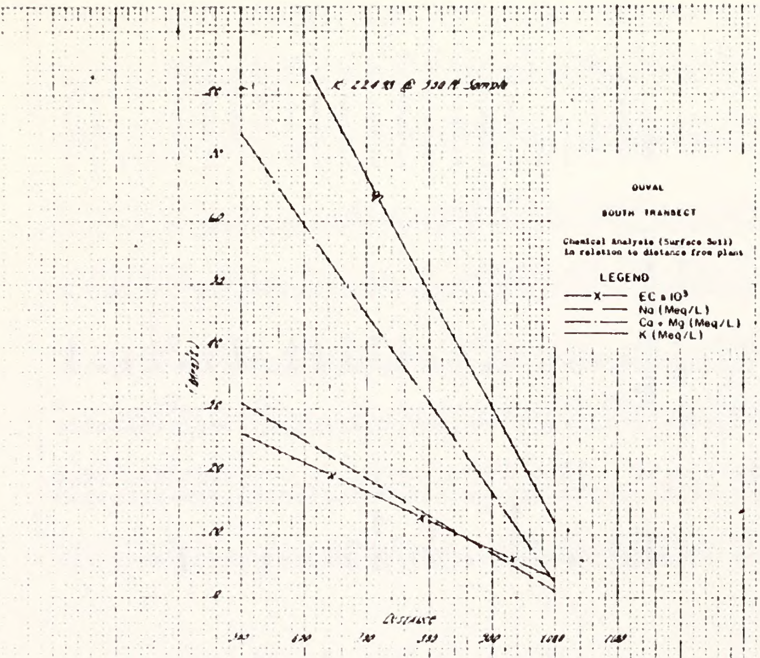
Lab.No.	Sample No.		pH	EC	Ca	Mg	Na	K	SAR
					- - - - - - - - - - -meq/1- - - - - - - - -				
799	P-7	3"-11"	7.37	31.40	178.37	37.32	50.98	91.23	4.91
800	P-7	24"-29"	7.36	17.00	152.89	39.35	13.89	3/27	1.41
801	P-8	0-4"	8.36	3.09	.96	.30	4.55	18.93	5.73
802	P-8	4"-12"	8.52	1.97	.21	.14	2.32	12.96	5.55
803	P-8	23"-28"	7.61	7.77	34.44	4.15	11.19	20.37	2.55
804	P-9	0-3"	7.64	11.48	36.14	6.98	22.60	47.90	4.57
805	P-9	3"-13"	7.85	12.30	14.11	5.52	37.47	57.19	11.96
806	P-9	29"-34"	7.37	24.30	54.09	87.93	68.50	26.69	8.13
807	P-10	0-3"	6.76	10.66	183.92	1220.62	17.64	164.18	.57
808	P-10	3"-15"	7.42	44.80	46.76	229.01	240.05	35.80	20.44
809	P-10	26"-30"	7.77	20.40	23.24	96.02	80.58	2.67	11.47
810	A-4 A	0-4"	7.46	11.90	2.07	1.50	27.98	67.25	20.94
811	A-4 A	4"-13"	8.17	10.67	2.77	1.08	27.44	51.66	19.73
812	A-4 A	25"-31"	7.67	1.44	1.19	.26	7.67	2.91	9.01
813	A-5	0-3"	8.27	4.09	13.71	.60	6.23	23.75	2.33
814	A-5	3"-11"	7.38	4.39	3.36	2.01	6.54	21.11	3.99
815	A-5	20"-25"	7.64	2.56	2.77	.64	5.31	10.68	4.07
816	A-6	0-3"	8.31	4.03	1.01	.30	5.49	27.05	6.78
817	A-6	3"-13"	7.97	5.44	4.77	.70	7.85	32.83	4.75
818	A-7	0-3"	7.78	10.34	11.82	1.85	15.61	57.94	5.97
819	A-7	3"-12"	7.76	9.26	15.71	1.82	10.06	41.07	3.40
820	A-7	20"-24"	7.62	3.95	6.38	.57	7.97	8.84	4.28
821	A-8	0-3"	8.17	17.00	2.55	1.66	13.28	142.95	9.08
822	A-8	3"-11"	7.97	14.10	4.06	1.16	8.38	111.06	5.19
823	A-9	0-4"	7.77	3.65	3.28	.42	2.74	20.79	2.01
824	A-9	4"-14"	7.64	2.95	8.12	.69	2.08	8.99	.99
825	W-1	0-4"	7.79	.82	4.30	.79	1.33	1.23	.83
826	W-1	4"-14"	7.47	.40	2.77	.30	.48	.31	.39

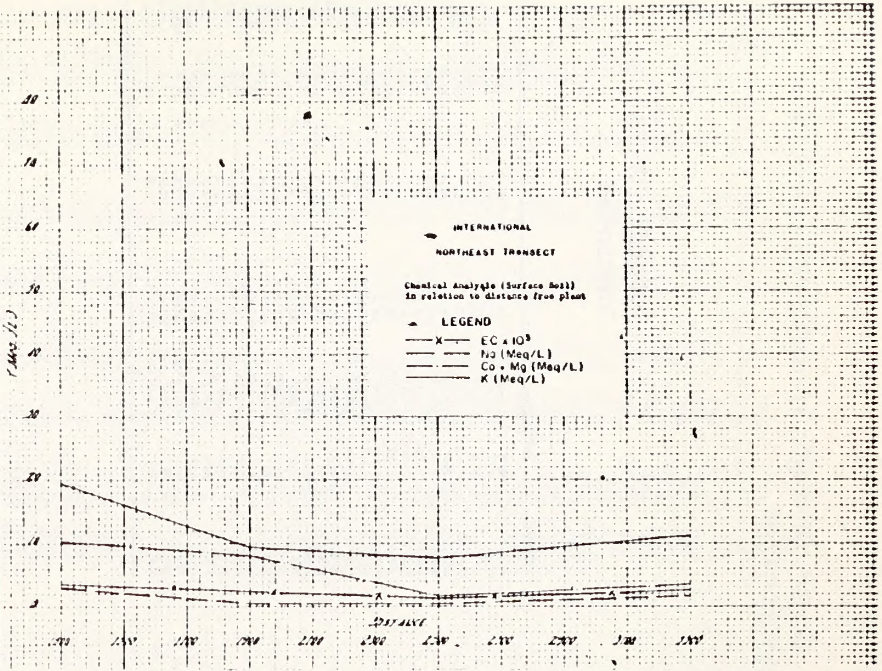
Lab No.	Sample No.		% Sand	% Silt	% Clay	Texture
801	P-8	0-4"	65.0	23.6	11.4	Sandy Loam
802	P-8	4"-12"	62.4	20.2	17.4	Sandy Loam
803	P-8	23"-38"	56.0	21.6	22.4	Sandy Clay Loam
804	P-9	0-3"	30.4	53.2	16.4	Silt Loam
805	P-9	3"-13"	39.0	38.6	22.4	Loam
806	P-9	29"-34"	46.4	38.8	14.8	Loam
807	P-10	0-3"	29.0	63.2	7.8	Silt Loam
808	P-10	3"-15"	24.4	71.4	4.2	Silt Loam
809	P-10	26"-30"	21.0	48.2	30.8	Clay Loam
810	A-4 A	0-4"	89.4	3.6	7.0	Sand
811	A-4 A	4"-13"	87.0	4.2	8.8	Loamy Sand
812	A-4 A	25"-31"	80.4	4.4	15.2	Sandy Loam
813	A-5	0-3"	93.0	3.2	3.8	Sand
814	A-5	3"-11"	93.4	.6	6.0	Sand
815	A-5	20"-25"	91.0	2.2	6.8	Sand
816	A-6	0-3"	82.4	8.8	8.8	Loamy Sand
817	A-6	3"-13"	78.0	10.2	11.8	Sandy Loam
818	A-7	0-3"	64.4	20.8	14.8	Sandy Loam
819	A-7	3"-12"	63.0	21.2	15.8	Sandy Loam
820	A-7	20"-24"	62.4	20.6	17.0	Sandy Loam
821	A-8	0-3"	94.2	2.0	3.8	Sand
822	A-8	3"-11"	91.4	3.6	5.0	Sand
823	A-9	0-4"	80.8	8.4	10.8	Sandy Loam
824	A-9	4"-14"	80.4	7.8	11.8	Sandy Loam
825	W-1	0-4"	90.2	2.0	7.8	Sand
826	W-1	4"-14"	84.4	2.6	13.0	Loamy Sand

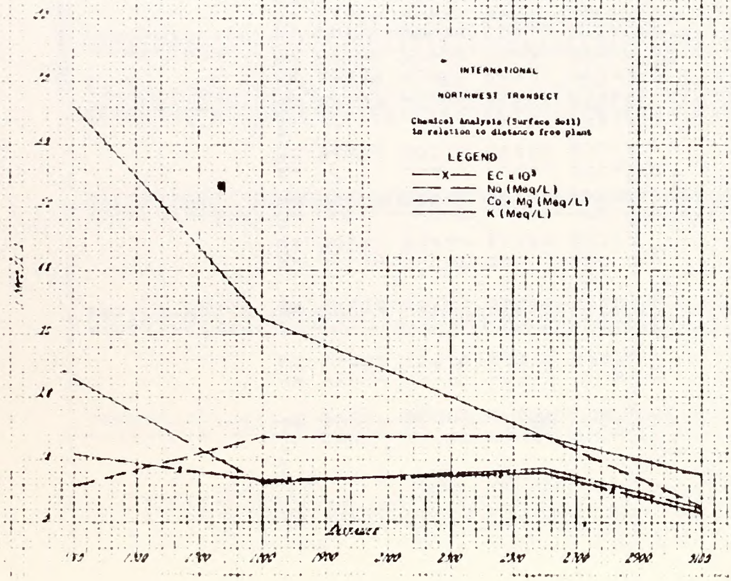
Lab No.	Sample No.	pH	EC x 10^3	Ca	Mg	Na	K	% Sand	% Silt	% Clay	Texture
				- - - - meq/1 - - - -							
651	Amax 1:0-1/2	7.43	75.40	28.15	42.60	336.81	733.91	90.2	4.0	5.8	Sand
652	2-4	8.24	7.22	.64	.37	9.71	53.00	91.4	2.6	6.0	Sand
653	12-14	7.47	12.30	14.83	7.22	24.73	76.03	91.8	3.4	4.8	Sand
654	15-17	7.36	11.90	20.26	8.55	27.76	66.97	89.0	4.8	6.2	Sand
655	30-36	7.81	3.49	1.06	.15	14.10	16.86	81.0	5.2	13.8	S.loam
656	48-54	7.50	1.10	1.53	.31	8.73	.66	74.6	9.2	16.2	" "
657	60-66	7.71	.63	.81	.20	5.89	.15	78.8	9.8	11.4	" "
658	72-80	7.90	.62	.63	.16	5.34	.12	82.8	6.2	11.0	L.sand
659	Amax 2:0-6	7.65	2.48	8.06	.67	3.26	11.13	87.0	3.6	9.4	" "
660	12-18	7.33	1.59	13.48	.90	1.24	1.04	84.6	4.0	11.4	" "
661	24-30	7.43	1.32	11.32	1.04	1.75	.07	78.6	4.2	17.2	S.loam
662	30-36	7.56	.45	2.93	.41	1.39	.06	82.8	4.4	12.8	" "
663	42-48	7.57	.44	2.91	.53	1.24	.03	79.3	4.4	16.3	L.sand
664	48-54	7.63	.49	3.09	.64	1.84	.05	73.4	6.2	20.4	SC loam
665	54-60	7.74	.57	3.80	.71	1.27	.18	60.0	11.0	29.0	SC loam
666	Amax 3:0-6	7.31	.92	5.04	.80	.76	1.64	93.4	1.2	5.4	Sand
667	12-18	7.29	.50	3.14	.47	.33	1.28	90.0	2.0	8.0	"
668	24-30	7.37	.27	2.08	.36	.31	.11	87.2	4.6	9.2	L.sand
669	30-36	7.50	.24	1.83	.30	.47	.09	89.0	3.4	7.6	Sand
670	48-54	7.74	.25	1.82	.22	.70	.06	82.2	4.6	13.2	L.sand
671	54-60	7.83	.29	1.49	.22	1.11	.03	68.0	9.0	23.0	SC loam
672	Amax 4:0-3	7.62	44.10	22.35	11.35	46.92	463.53	63.6	21.2	15.2	S loam

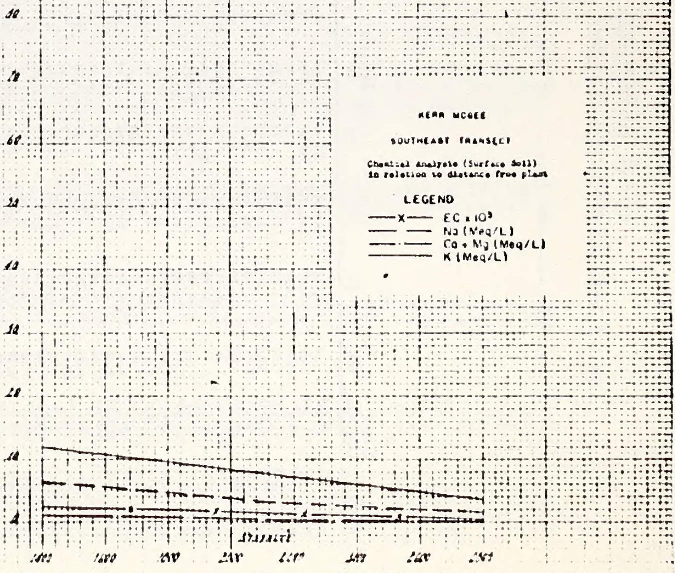
SOIL SAMPLE LOCATION

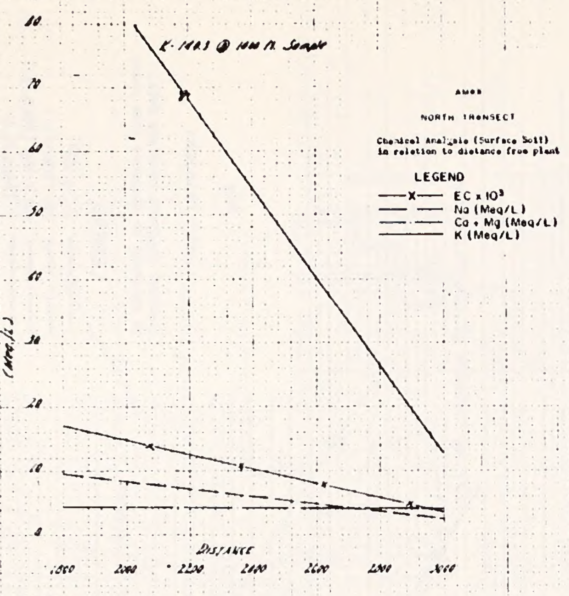
Plant	Chemical Analysis Transect	Samples
IMC	NW	I-1 through I-4
	NE	I-5 through I-8
MCC	W	M-1
	N	M-2
Kerr Mc-Gee	SE	K-1 through K-3
	NE	K-4 through K-6
	W	K-7 through K-8
National	NE	N-1 through N-3
	South	N-4 through N-6
Nat. Eddy Shaft	South	N-7 through N-8
Duval	South	D-1 through D-2
	East	D-3 through D-6
	North	D-7 through D-8
PCA	NE	P-1 through P-4
	North	P-5 through P-8
	West	P-9 through P-10
Amax	SE	A-1 through A-2
	(Control)	A-3
	NW	A-4
	W	A-4A through A-7
	North	A-8 through A-9

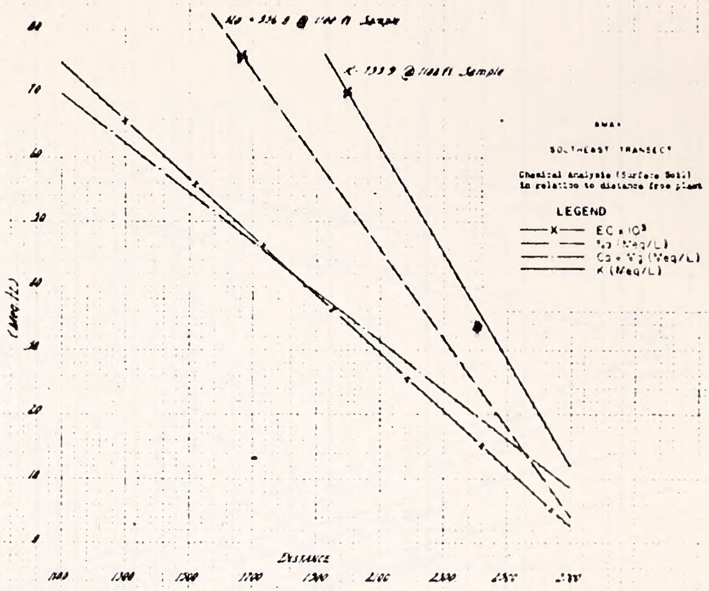

K 22.4 ft @ 330 ft Sample
OUVAL
SOUTH TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
EC x 10³
Na (Meq/L)
Ca + Mg (Meq/L)
K (Meq/L)
(Meq/L)
Distance

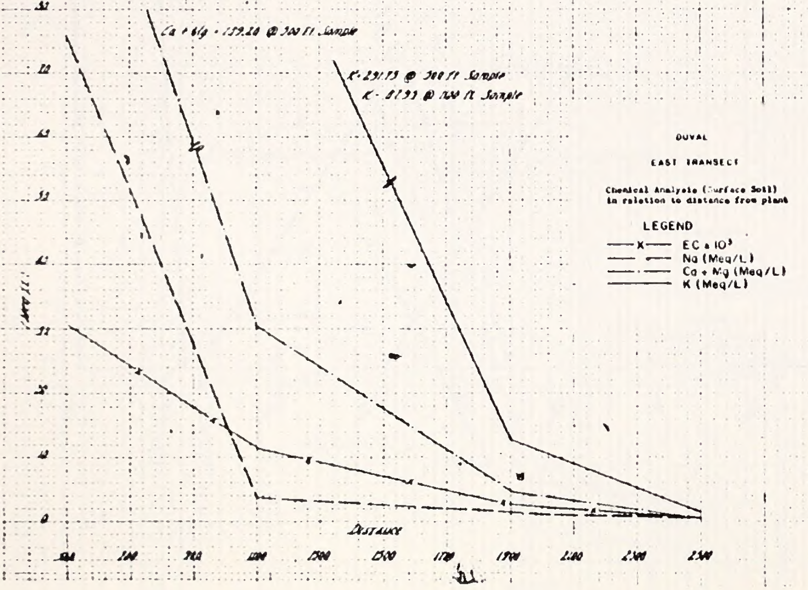

INTERNATIONAL
NORTHEAST TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
EC x 10³
Na (Meq/L)
Ca + Mg (Meq/L)
K (Meq/L)
(Meq/L)
Distance

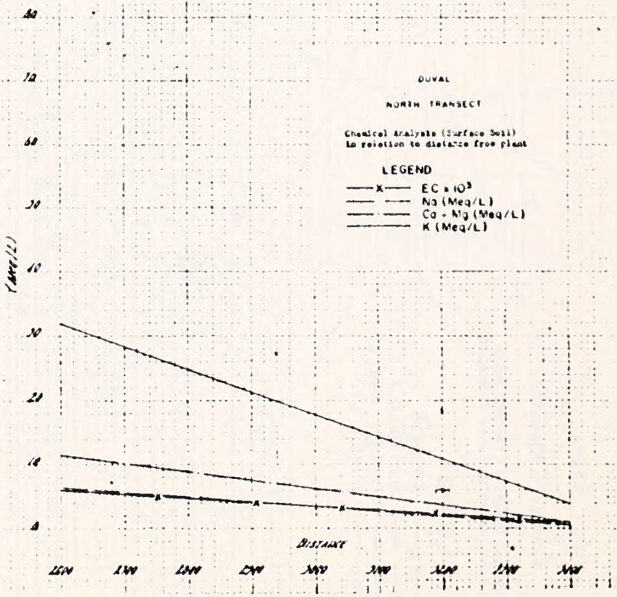

INTERNATIONAL
NORTHWEST TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
EC x 10³
Na (Meq/L)
Ca + Mg (Meq/L)
K (Meq/L)
(Meq/L)
Distance

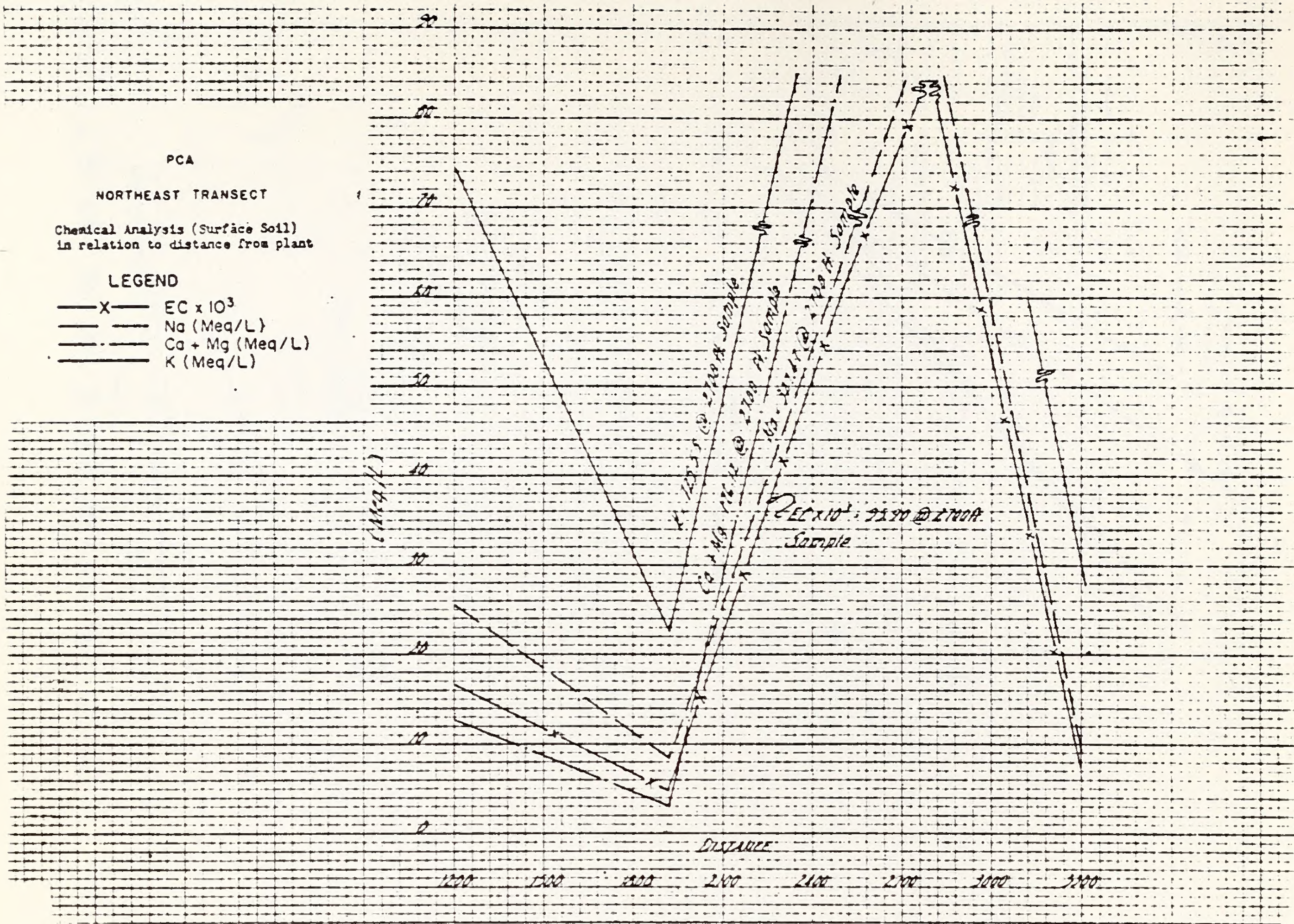

KERR MCGEE
SOUTHEAST TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
EC x 10³
Na (Meq/L)
Ca + Mg (Meq/L)
K (Meq/L)
Meq/L
Distance


AMAX
NORTH TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
—X— EC x 10³
— — Na (Meq/L)
—·— Ca + Mg (Meq/L)
—— K (Meq/L)
K-1483 @ 1800 ft. Sample
(Meq/L)
DISTANCE
1800
2000
2200
2400
2600
2800
3000


AMAX
SOUTHEAST TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
—X— EC x 10³
— — Na (Meq/L)
—·— Ca + Mg (Meq/L)
—— K (Meq/L)
Na = 336.8 @ 1100 ft Sample
K-133.9 @ 1100 ft Sample
(Meq/L)
DISTANCE
1100
1300
1500
1700
1900
2100
2300
2500
2700


DUVAL
EAST TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
—X— EC x 10³
— — Na (Meq/L)
—·— Ca + Mg (Meq/L)
—— K (Meq/L)
Ca + Mg = 159.20 @ 300 ft Sample
K-291.73 @ 300 ft Sample
K-87.93 @ 700 ft Sample
(Meq/L)
DISTANCE

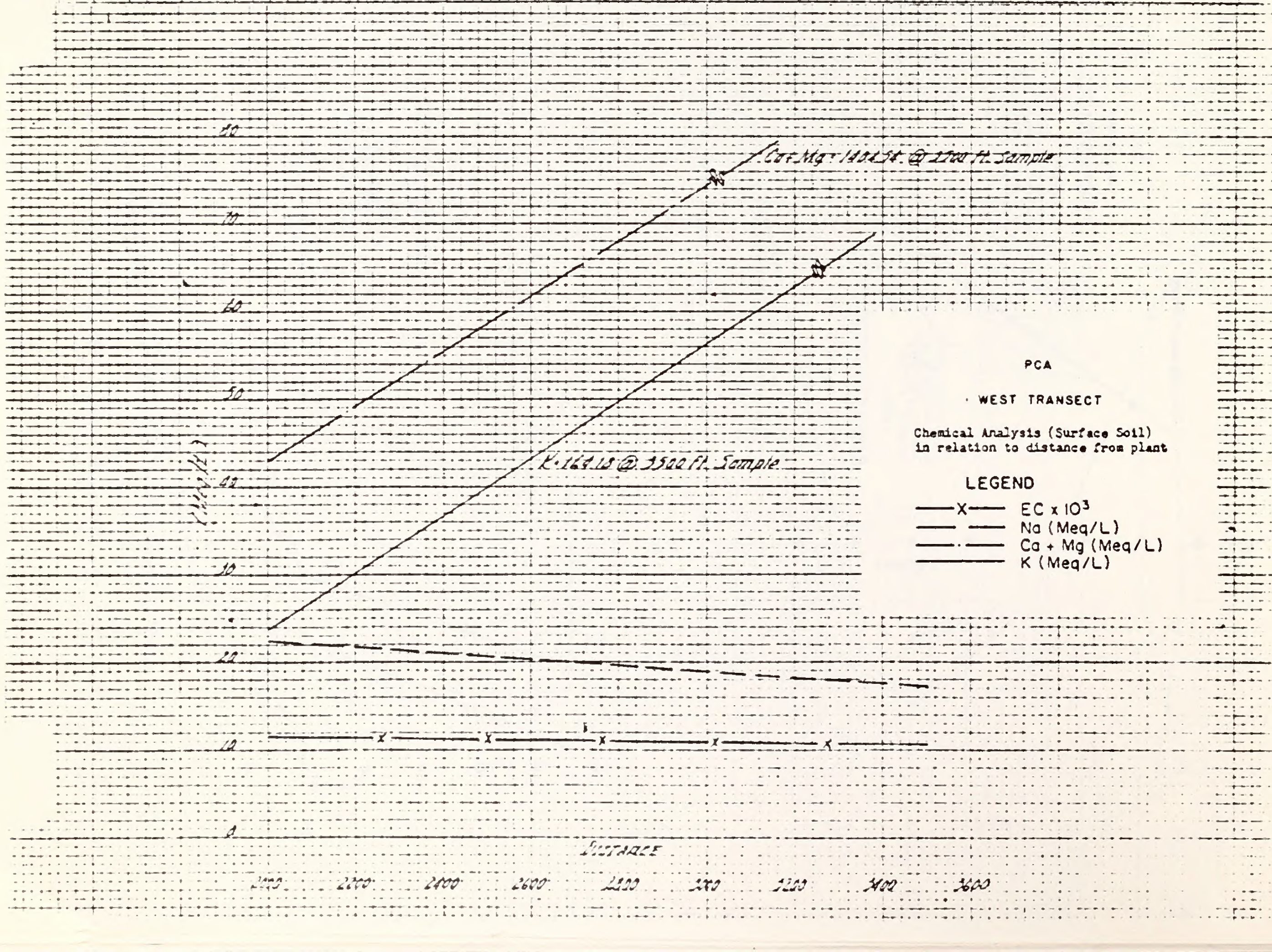

DUVAL
NORTH TRANSECT
Chemical Analysis (Surface Soil)
in relation to distance from plant
LEGEND
—X— EC x 10³
— — Na (Meq/L)
—·— Ca + Mg (Meq/L)
—— K (Meq/L)
(Meq/L)
DISTANCE



PCA

NORTHEAST TRANSECT

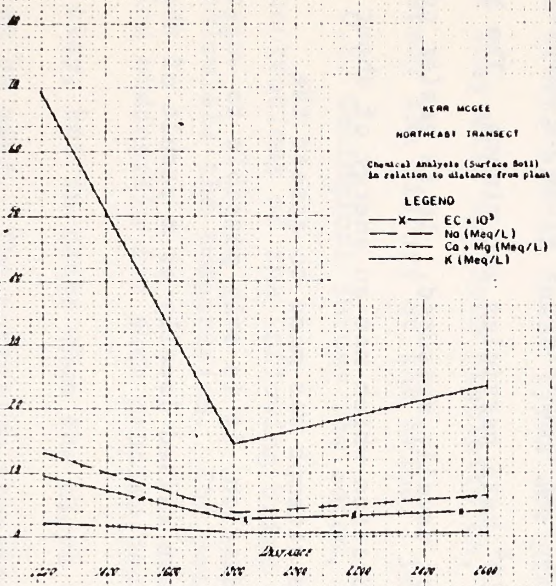
Chemical Analysis (Surface Soil) in relation to distance from plant



PCA

WEST TRANSECT

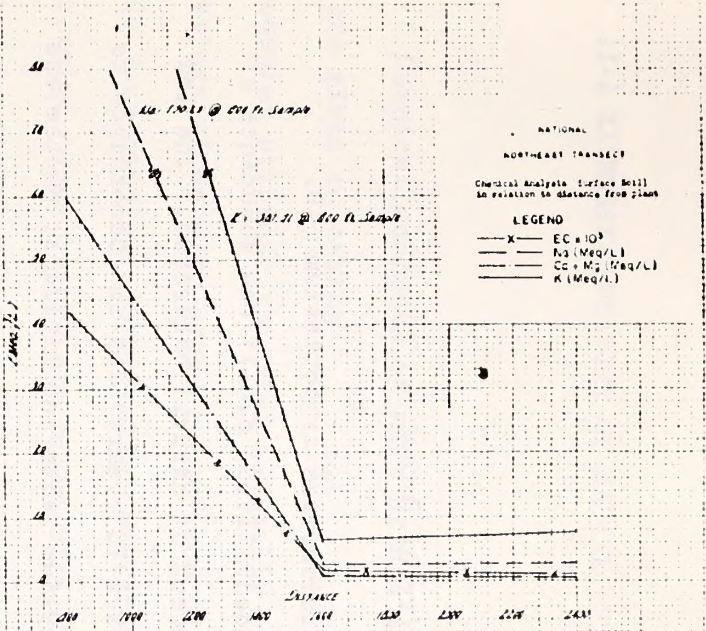
Chemical Analysis (Surface Soil) in relation to distance from plant



KERR MCGEE

NORTHEAST TRANSECT

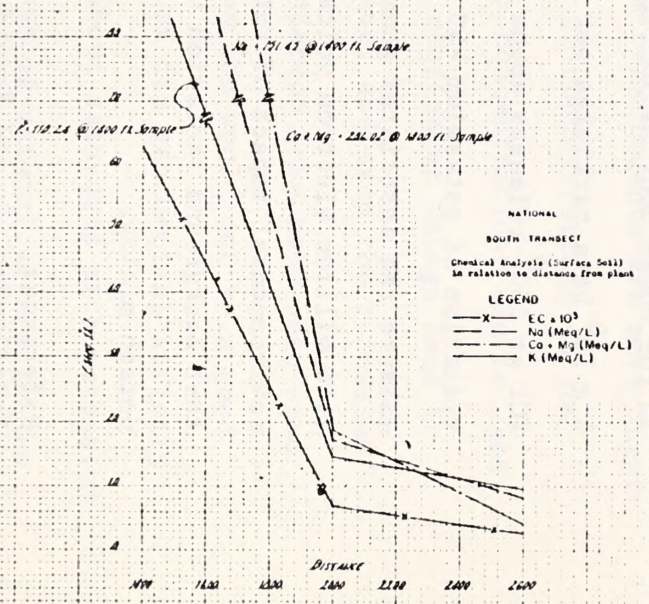
Chemical Analysis (Surface Soil) in relation to distance from plant



NATIONAL

NORTHEAST TRANSECT

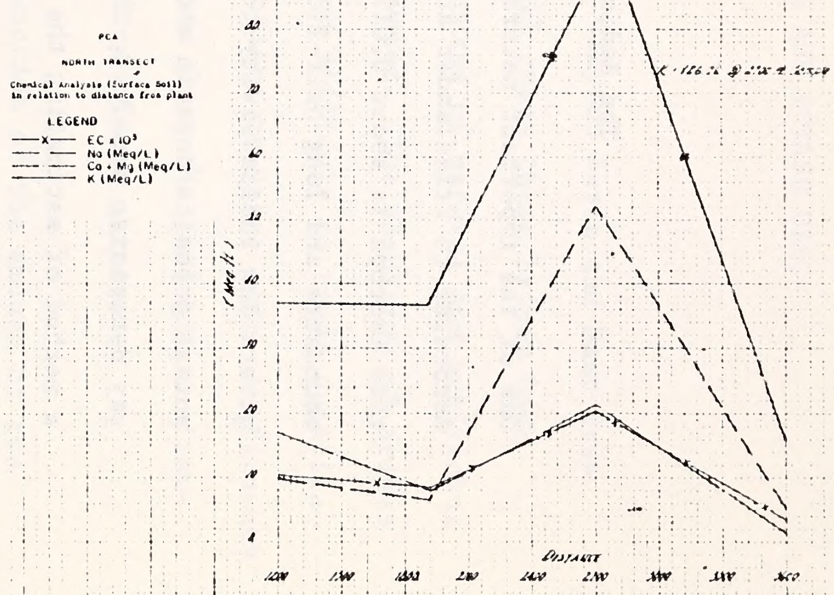
Chemical Analysis (Surface Soil) in relation to distance from plant



NATIONAL

SOUTH TRANSECT

Chemical Analysis (Surface Soil) in relation to distance from plant



PCA

NORTH TRANSECT

Chemical Analysis (Surface Soil) in relation to distance from plant

The Radioactivity of Potash

One of the important natural radioisotopes is potassium -40. According to Friedlander and Kennedy (1955, p.417) the abundance of this isotope is about 0.0119 precent of natural potassium. The low abundance and long half-life (1.2 x 10^9 years) act in concordance to give a low radioactivity to potassium salts and minerals; nontheless potash deposits contain enough radioactivity to be detected by gamma ray detectors; moreover, this radioactivity is sufficient to provide a method of estimating the grade of potash ore.

According to Glasstone (1967, p. 744) the amount of potassium -40 in the human body is sufficient to cause the release of more than 1 x 10^6 beta particles per minute. By comparison a litre of saturated KCl at $20C^0$ releases about 3 x 10^4 beta particles per minute. The beta radiation of potassium -40 is not usually measured. It is easier to measure the associated gamma radiation which has an energy of about 1.46 million electron volts. No attempt was made to assess the environmental impact of this radiation; it is only possible to suggest that background radiation has been raised locally as a result of the potash mining.

References
Friedlander, G. and Kennedy, J.W., 1962, Nuclear and radiochemistry: New York, John Wiley and Sons

Glasstone, S., 1967, Atomic Energy: Princeton, New Jersey, van Nostrand Company, Inc.

THE SOLUBILITY OF HALITE, SYLVITE AND POTASH ORES

Chemical analyses of many brines in the Clayton Basin and Nash Draw are given in tables _____ and _____. In all cases these brines have complex origins, composed generally of mixtures of natural and artificial brines along with storm runoff and ground water. The chemistry of brines is very complex, imperfectly understood, and difficult to treat quantitatively. When brines are mixed with other brines or water some constituents may precipitate while others may be dissolved from the geologic environment due to the more corrosive characteristics of the mixture.

The chemical composition of a brine is a function of the amount of the various constituents in the geologic environment and of the geochemical activity of the various constituents. Some constituents are more inert than others and if these types are present in concentrations so low that they will not form precipitates, their concentrations can be used to study the history of the brine. In the studies at Malaga Bend by the U.S. Geological Survey the boron, bromide, and even the potassium concentrations of the inflowing brine to Anderson Lake have been used to calculate the evaporation. The potassium ion would not be a good choice ordinarily for such studies because of its geochemical affinity for clay, but in cases when the clays are about saturated with potassium it can be used. The potassium concentrations of natural waters in New

THE SOLUBILITY OF HALITE, SYLVITE AND POTASH ORES (cont)

Mexico rarely exceed 20 mg/l (milligrams per litre), but in the area of this study these natural concentrations are much greater. For example, the brine from well USGS 8 table ____ has been analyzed periodically for many years, and until a few years ago when the casing of this well was damaged the concentrations were always about 4,500 mg/l. At present the concentration is less probably because of dilution of fresher water through the damaged casing.

Most readers will find the study of the composition of brines in table ____, easier if data are given for comparison. At normal temperatures the solubility of halite and sylvite are about equal to 350 g/l (grams per litre) therefore a brine saturated with halite would have a composition of approximately 138,000 mg/l sodium and 212,000 mg/l chloride and a brine saturated with sylvite would have a composition of 184,000 mg/l potassium and 166,000 mg/l of chloride.

For brines saturated with potash ores the concentrations of sodium, potassium, and chloride are intermediate to the values given for pure halite and pure sylvite. Some notion of these concentrations are given by analyses of three ore samples collected from refineries in the area. The assays of these ores are given in the following table.

	Assay (Percent)					
Company	sodium	potassium	chloride	sulfate	bromide	boron
Duval Corp.	14.0	30.4	51.7	0.24	0.24	.0009
AMAX Chem. Corp.	16.3	31.0	53.5	.56	.11	.017
Potash Co. Amer.	20.6	23.1	53.1	-	.28	.0006

THE SOLUBILITY OF HALITE, SYLVITE AND POTASH ORES (cont)

Assuming a solubility of about 350 g/l the saturated brines composed of these ores would have approximately the following compositions (mg/l).

Company	sodium	potassium	chloride	bromide	boron
Duval Corp.	49,000	106,000	181,000	850	3
AMAX Chem. Corp.	57,000	108,000	187,000	394	59
Potash Co. Amer.	72,000	81,000	186,000	983	2

The assays of these ores were computed from analyses made by a laboratory of the U.S. Geological Survey, and it should be stated that the chemists might have done better had they been furnished a larger sample. Most constituents are about correct but the bromide concentrations appear to be too great.

POTASSIUM OXIDE

Throughout this report there are references to chemical analyses and computations made therefrom which need explanation.

The concentration of potassium in ores and finished products is reported in numerous ways for various reasons. It is commonly reported as potassium oxide (K_2O) which is hereafter although there is no mineral of this composition in the potash deposits. Potassium oxide is a standard to which the purity or the composition of an ore or product can be compared, and the calculations to convert from this standard to actual compounds or ores is relatively simple. Data for making these calculation are obtained from tables showing atomic weights of the elements. The atomic weights of some elements are given in the following table.

Element	Chemical Symbol	Atomic Weight
Potassium	K	39.10
Chloride	Cl	35.45
Oxygen	O	16.00
Sulfur	S	32.06
Sodium	Na	23.00

From these data the molecular weights of K_2O, KCl, K_2SO_4, and NaCl can be calculated as follows:

K_2O (2 x 39.10) + 16.00 = 94.2

POTASSIUM OXIDE continued

KCl $39.10 + 35.45 = 74.55$

K_2SO_4 $(2 \times 39.10) + 32.06 + (4 \times 16.00) = 174.26$

$NaCl$ $23.00 + 35.45 = 58.45$

If it is desirable to calculate the weight of potassium in one ton (2,000 pounds) of ore containing 50 percent KCl the calculation would be $2{,}000 \times .5 \times \frac{39.10}{74.55} = 524$ pounds but if the weight of potassium is expressed as K_2O the calculation would be $2{,}000 \times .5 \times \frac{39.10}{74.55} \times \frac{94.2}{78.2} = 632$ pounds K_2O.

A more practical problem is to calculate whether there is more potassium oxide in a ton of pure KCl or a ton of pure K_2SO_4, and this calculation is:

KCl $$2{,}000 \times \frac{39.1}{74.55} \times \frac{94.2}{78.2} = 1{,}263 \text{ pounds } K_2O.$$

K_2SO_4 $$2{,}000 \times \frac{78.2}{174.26} \times \frac{94.2}{78.2} = 1{,}081 \text{ pounds } K_2O.$$

From these calculations it is evident that a ton of pure KCl contains more potassium than a ton of pure K_2SO_4. The weight of potassium in a ton of pure KCl is: $2{,}000 \times \frac{39.10}{74.55} = 1{,}049$ pounds and in a ton of pure K_2SO_4 is: $2{,}000 \times \frac{78.2}{174.26} = 898$ pounds.

The leakage of brine form Anderson lake is reported in tons of chloride because the chloride concentration of brine is easliy determined and is related to the weight of common salt NaCl by the ratio $\frac{58.45}{35.45}$ therefore, a ton of chloride is equivalent to $2{,}000 \times \frac{58.45}{35.45} = 3{,}300$ pounds or 1.65 tons of sodium chloride.

MINERALOGY

This report makes reference to numerous minerals and rocks. Most of these references are to evaporite minerals that were formed by precipitation from evaporating sea water. Most of the rocks are composed of several minerals but some such as limestone, dolomite, and anhydrite are composed dominantly of a single mineral such as calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$) or anhydrite ($CaSO_4$). In general, the minerals are impure or contain various amounts of elements not normally shown in their chemical compositions. A few such as montmorillonite ($Al_2Si_4O_{10} .x\ H_2O$) have no pure chemical composition and their formulae give only approximations of their composition. There are an infinite number of chemical formulas for such minerals. The chemical compositions of many minerals that occur as evaporite deposits are given in table _____.

MINERALS OF MARINE EVAPORITE DEPOSITS *

Mineral	*Formula*
Anhydrite	$CaSO_4$
Bischofite	$MgCl_26H_2O$
Blodite	$Na_2Mg(SO_4)_24H_2O$
Carnallite	$KMgCl_36H_2O$
D'Ansite	$Na_{21}MgCl_3(SO_4)_{10}$
Epsomite	$MgSO_47H_2O$
Gypsum	$CaSO_42H_2O$
Glaserite	$K_3Na(SO_4)_2$
Glauberite	$Na_2Ca(SO_4)_2$
Gorgeyite	$K_2Ca_5(SO_4)_6H_2O$
Halite	$NaCl$

MINERALS OF MARINE EVAPORITE DEPOSITS (cont)

Mineral	Formula
Hexahydrite	$MgSO_4 6H_2O$
Kainite	$4(KMgClSO_4)11H_2O$
Kieserite	$MgSO_4 H_2O$
Langbeinite	$K_2Mg_2(SO_4)_3$
Leonbeinite	$MgSO_4 4H_2O$
Leonite	$K_2Mg(SO_4)_2 4H_2O$
Loweite	$6Na_2SO_4 7MgSO_4 15H_2O$
Mirabilite	$Na_2SO_4 10H_2O$
Pentahydrite	$MgSO_4 5H_2O$
Polyhalite	$Ca_2K_2Mg(SO_4)_4 2H_2O$
Schoenite	$K_2Mg(SO_4)_2 6H_2O$
Sylvite	KCl
Syngenite	$K_2Ca(SO_4)_2 H_2O$
Tachhydrite	$CaMg_2Cl_6 12H_2O$
Thenardite	Na_2SO_4
Vanthoffite	$Na_2Mg(SO_4)_4$

*Ref: (After Adams, S.A., 1969, p. 19)

Experimental Operations - Solution Mining

Solution mining techniques enable the extraction of ores soluble in liquid media. The media employed is usually water because it is the most commonly available liquid at the lowest cost. The main advantage of this mining method lies in the fact that rock beds too deep, too thin, too poor, or overlain by hazardous or impenetrable rocks such that ores cannot economically be extracted by more prevalent mining methods, are made accessible by the drilling of holes and subsequent removal of mineral values by solution.

Solution mining requires a readily available and adequate water supply, a sufficient number of well bores through the bed to be mined, and either communication by flow of water among wells or the development of a cavity around individual wells. In addition, processing facilities at land surface are necessary to recover the mineral values in solution. The quality of water is important in solution mining. For maximum efficiency the water should be pure, but it is impractical to find uses for large volumes of pure water. At places where there are very pure potash deposits, it would be theoretically possible to use brines for solution mining; however, it seems likely that such deposits are extremely rare and local in nature. From the existing data it appears that there are no abundant local supplies of water of sufficiently good quality for extensive solution mining.

In solution methods of mining potash, the most soluble salts of potassium are the target. The salt commonly sought is potassium chloride and the salt is either dissolved selectively or all soluble salts of potassium, and usually, sodium, are taken and potassium compounds are later recovered by processing.

Wells used for solution mining must be carefully cased on the top of the soluble rocks. Casing is solidly cemented to assure control of the solvent and to prevent brine loss and environmental damage above the soluble rock beds. Wells to be used individually for solution mining are completed with dual strings of pipe. The annulus between the inner and outer strings usually serves to introduce the water into the rock bed at the outset and the inner string serves as the solution recovery string. After salt recovery is initiated flow may be reversed in order to obtain greater yields of saturated brine. Wells to be used in conjunction with others are completed with single strings of pipe and communication of fluids is established by fracturing the rock among wells. Upon completion of fracturing, commonly by pressure overload and shock techniques, the water is directed by pumps from well to well along the fractures and solution and expansion of cavities take place.

Provision must be made at land surface for lifting and adjusting the production strings of pipe in order to maintain close and constant control of the flow of water and brines introduced into the soluble rocks. Direction and rate of dissolution of soluble rock is controlled laterally by control of introduced water or brine and this dissolution is controlled vertically by the introduction of an inert fluid blanket at the top of the soluble bed. This blanket is usually composed of a hydrocarbon such as diesel oil, which is less dense and not readily mixable with water or brine, and therefore floats at the top of the brine and prevents upward progress of dissulution into barren rock. Dissolution downward, appreciably below the end of the production string(s), is largely prevented by the dense layer of saturated brine which collects in the lower part of the cavities created.

The solution mining of potash can be done by removal of all soluble salts, in which case fresh water is the desirable solvent. Salts of potassium may be selectively dissolved and transported in brine saturated with salts not wanted, or a brine saturated with undesirable salts can be heated and introduced into the potash-bearing intervals thus taking advantage of the increasing solubility of potassium chloride with temperature, compared to the relatively constant solubility of the unwanted salt, such as sodium chloride. The liquid media (solvent) and detail of method are determined by the physical and chemical details of the rock interval being mined, and especially by the minerals present.

Solution methods work best and most efficiently in thick beds protected by a competent roof structure of overlying rock. The lateral extent of developed cavities determines the time and extent of caving. Cavities are not permitted to enlarge beyond the limits of the strength of overlying rock beds which form the cavity roof. Relatively large spans at the roof can be supported by the hydrostatic pressure of the brine. The hydrostatic pressure can neutralize about one-half of the normal overburden pressure.

Experimental solution mining of salts of potassium has been done in England, Canada, and the United States. Experiments which might have been completed in other countries possessing appreciable potash deposits, primarily Germany and the Soviet Union, are not well documented in the literature. There are two solution potash mines in North America at the present, one near Belle Plain, Saskatchewan and the other near Moab, Utah. The Canadian operation started in 1964, but little information exists on details of method. The operation in Utah has been ongoing for several year, but again operation detail is not generally available. Solution mining in the Carlsbad mining district must be regarded as experimental at best. Field tests of solution mining were conducted in the mining district in the late 1960's by the Continental Oil Company (Davis and Shock, 1970, p. 106-109). Although testing was successful, there has been no attempt to "scale-up" the field tests and initiate a viable mining operation.

It is believed that solution mining will not become a major mining process in this area within the near future, and because of this belief no attempt was made to examine the detailed engineering problems associated with the process. It seems likely that if an area could be found where the geologic environment is favorable for the process, other problems such as the procurement of adequate water supplies and the disposal of waste materials would weigh heavily against the prospect of the success of such a venture.

Experimental Operations-Polyhalite

Polyhalite deposits are a potential potash resource, but are not now mined and processed. Research and development work by the U. S. Bureau of Mines on processing of polyhalite was reported by Conley and Partridge (1944). A carload of ore for use in the Bureau's studies was obtained from U. S. Potash Company during shaft sinking operations in 1931. The ore contained the equivalent of 76 percent polyhalite, 13 percent halite, and 8 percent anhydrite (calcium sulfate). Polyhalite constituents corresponded to 22 percent potassium sulfate, 15 percent magnesium sulfate, and 34 percent calcium sulfate in the sample. The flowsheet on page is perhaps the simplest of the nine processes investigated by the Bureau. In the laboratory this process recovered 33 percent of the potash as potassium sulfate and 48 percent as potassium magnesium sulfate for 81 percent overall recovery. The processing of polyhalite ore is based initially on its natural insolubility in water which permits selective leaching of halite, and of the subsequent change to water solubility of potassium sulfate and magnesium sulfate when polyhalite is heated to between 570° and 930° F, with evolution of combined water from the polyhalite crystal. The calcium sulfate component of the polyhalite remains insoluble. Numbered operating steps in the flowsheet are summarized as follows:

Step 1, Dry Crush and Size - The ore is dry crushed in hammer mills and sized to pass a 10-mesh screen.

Step 2, Leach NaCl, Debrine - The crushed ore is leached with water to dissolve halite (NaCl), and the sodium chloride brine is separated from the polyhalite by thickening and filtration. About 80 percent of the halite brine is discarded and the remainder is used in washing a subsequent leach residue. The discarded brine would be discharged into a tailings pond where the water would dissipate by evaporation or seepage leaving a residue of sodium chloride.

Step 3 Calcine at 930° F. (500° C.)- Moist polyhalite is calcined by direct firing in a rotary kiln to remove the water of crystallization from the polyhalite crystal and to disrupt the crystal lattice. About 0.8 tons of leached and calcined polyhalite is obtained per ton of polyhalite ore.

Step 4, Leach Calcine - The calcine is leached at 210° F. countercurrently with weak liquor and dilute brine in two stages to dissolve potassium and magnesium sulfates. The leach residue, composed mainly of calcium sulfate, is debrined by thickening and the thickener underflow discarded. Leaching of the sulfates is accelerated by the presence of sodium chloride in the leach solution. About one-fifth of the halite brine from Step 2 is added to the wash water that subsequently becomes the leach solution in Step 4. About 2.5 tons of sulfate brine is made per ton of calcine leached.

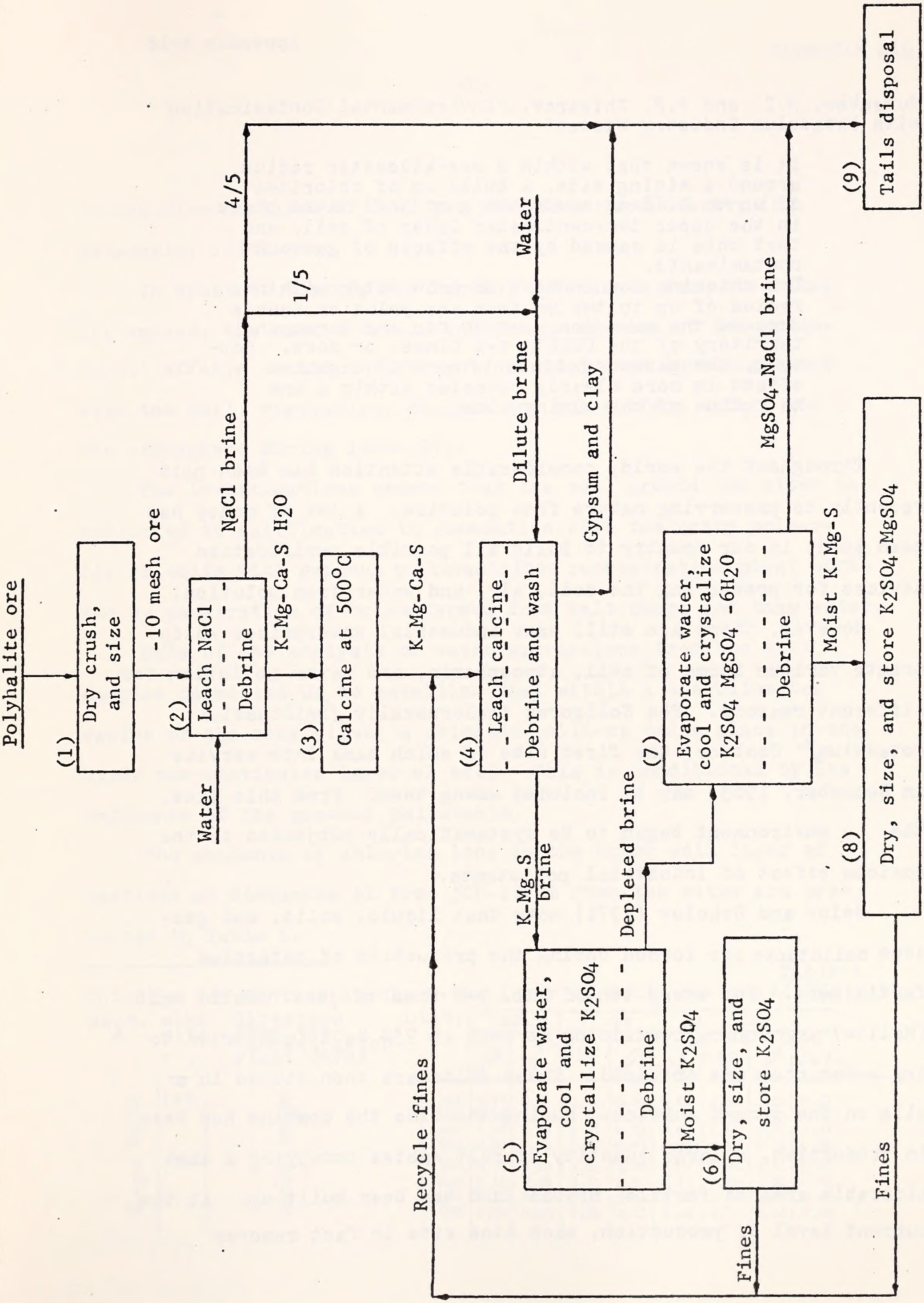
Step 5, Evaporate Water, Cool, and Crystalize Potassium Sulfate Debrine - About 55 percent of the water in the sulfate brine is evaporated, and the concentrated brine cooled to 85° F. in vacuum crystallizers to form potassium sulfate crystals. These are separated from the brine by thickening and filtration.

Step 6 - Dry, size, and store Potassium Sulfate - Moist potassium sulfate is dried in a rotary kiln, sized, and stored. Fines are releached in Step 4. The product contains about 89 percent potassium sulfate, four percent magnesium sulfate, six percent calcium sulfate, one percent halite.

Step 7, Evaporate Water, Cool, and Crystallize Potassium Magnesium Sulfate, Debrine - Depleted sulfate solution from Step 5 is evaporated further to remove 70 percent of the residual water, then cooled to 85° F to crystallize potassium magnesium sulfate. The crystals are separated from the brine in centrifuges, and the brine is discarded.

Step 8, Dry, size, and Store Potassium Magnesium Sulfate Moist crystals are dried, sized, and stored. Fines are releached in Step 4. The product contains about 52 percent potassium sulfate, 43 percent magnesium sulfate, five percent halite.

Step 9, Tails Disposal - Liquid wastes are comprised of about one-half ton NaCl brine from Step 2, and one fourth ton spent mixed brine from Step 7 per ton of ore. The thickener underglow slurry discarded from Step 4 contains about one-half gypsum and one-half ton water per ton of ore. Waste solids and brine are impounded, with subsequent solar evaporation of the brines.


Polyhalite ore
(1)
Dry crush, and size
-10 mesh ore
Water
(2)
Leach NaCl
Debrine
NaCl brine
4/5
1/5
K-Mg-Ca-S H$_2$O
(3)
Calcine at 500°C
K-Mg-Ca-S
(4)
Leach calcine
Debrine and wash
Dilute brine
Water
Gypsum and clay
Recycle fines
K-Mg-S brine
(5)
Evaporate water, cool and crystallize K$_2$SO$_4$
Debrine
Moist K$_2$SO$_4$
(6)
Dry, size, and store K$_2$SO$_4$
Fines
Depleted brine
(7)
Evaporate water, cool and crystallize K$_2$SO$_4$ MgSO$_4$ ·6H$_2$O
Debrine
MgSO$_4$-NaCl brine
Moist K-Mg-S
(8)
Dry, size, and store K$_2$SO$_4$-MgSO$_4$
Fines
(9)
Tails disposal

Turenkov, N.I. and P.F. Zhigarev, "Environmental Contamination with Potassium Industry Wastes"

It is shown that within a one-kilometer radius around a mining site, a build-up of chlorides of up to 2.28 mg·equiv/100 g of soil takes place in the upper two-centimeter layer of soil, and that this is caused by the effects of gaseous contaminants.
The chlorine ion content of show water within a radius of up to two km from the polution source exceeds the mean ion content for the European territory of the USSR by two times, or more. However, the gaseous pollutants' zone of negative effect is more clearly revealed within a one km radius of the mining site.

Throughout the world, considerable attention has been paid recently to preserving nature from polution. A lot of money has been spent in our country to build all possible purification devices for preserving the soil, air, and water from polution.

However, there are still many industrial enterprises which create various forms of soil, atmospheric, and water pollution for different reasons. The Soligorsk "Beloruskaliy /Belorussian Potassium/" Combine, the first site of which came into service in December, 1963, may be included among them. From this time, the environment began to be systematically subjected to the noxious effect of industrial pollutants.

Belov and Sokolov (1971) note that liquid, solid, and gaseous pollutants are formed during the production of potassium fertilizers. For every ton of KCl, 3-4 tons of just solid salt (Halite) pollutants, containing as much as 95% NaCl (converted to dry substance), are obtained. These salts are then stored in a pile on the ground surface. During the time the combine has been in production, a large quantity of salt wastes occupying a considerable area of fertile, arable land has been built up. At the current level of production, each mine site in fact removes twenty-five hectares of land per year from productivity (cf. Astashkin, 1970).

In order to clarify how harmful substances from the sites are spread, the hazard level, and the boundaries of the pollutants' effects on the environment, we conducted investigations with the soil, vegetation, surface and sub-surface water, and the atmosphere during 1969-1971.

The investigations showed that the soil around the sites is subjected to salification in connection with the entry primarily of salts with gaseous pollutants from concentration plant works and by penetration of brine formed from salt dumps and thaw water.

Data of the analysis of water extractions from the soil samples permitted us to establish that within a one-kilometer radius of the mine sites, a chloride build-up takes place in the upper two-centimeter layer of soil. This is conditioned by the influence of the gaseous pollutants.

The contents of chlorine ions in the upper soil layer of sections at distances of from 500-1000m from the sites are presented in Table 1.

Table 1

Chlorine ion Content in the 0-2cm Layer of Soil, mg·equiv/100g soil

Sect. #	mine site	Direction from the Concentration Plant Works	Dist, m	1969		1970			1971		
				sum.	fall	spr.	sum.	fall	spr.	sum.	fall
15	1st	N	500	2.27	0.06	0,46	0,59	0,09	2,22	2.28	0,52
17		NW	500	3,78	0,25	1.39	0.65	0,05	1,87	1,91	0,33
20		N	1000	1,33	0.13	0.67	0,21	0,04	0.59	0,26	0,09
21		S	500	0,30	0,16	0,72	0,04	0,09	0,49	0.25	0,05
8	2nd	N	500	0,19	0.03	1.00	0,05	0,08	0,49	0,03	0,05
8a		N	1000	0,16	0.05	0,49	0.04	0,14	0.35	0.05	0,08
9		N	500	0.24	0.04	0,77	0.85	0,40	0,89	0,62	0,07
10		S	500	0,09	0,03	0,68	0,23	0,09	0,71	0,13	0,08

According to Bazilevich and Pankova (1968;1970), soils are considered to be salty when in one layer the Cl ion content exceeds 0.3mg·equiv/100g of soil. As seen from Table 1, in all of the spring, and in several summer samples, the chlorine ion content exceeds the norm by several times. This is explained by the fact that in the spring, the soil still lacks a solid vegetational covering, and the deposits are small; therefore, the salty dust settling out from the smoke wastes builds up on the surface. In the summer, the dust is caught by the vegetation and little falls onto the soil. It is precisely for this reason that the Cl ion content in the summer samples of section 15 for 1967-71 (vegetable garden plots), sections 17 and 20 for 1969, and section 9 for 1971 remain fairly high. It must be noted that potato crops catch the dust less effectively than other agricultural crops.

In the fall, the salts settling on the soil migrate into lower layers along with atmospheric deposits; therefore their presence in the 0-2 cm layer is insignificant.

Beside the basic, more or less regular soil pollution by gaseous wastes from the concentration plant works, there is also local salification of individual sectors by brines entering the fields from salt dumps and slurry repositories with thaw and rain water. A series of authors (Astashkin, 1970; Markevich and Vasil'chenko, 1965; Ovchinnikov, 1955; Ewert and Dässler, 1967)

//Tr. note--This is possibly an incorrect citation. In the text, the work is referred to by number (11). In the next sentence (q.v.), the author refers to "Jakush (11)," but the entry number in the bibliography for this work is 10//

have pointed out the salinization of soil by brines around mining sites. According to Jakush's data (Jakush, 1970), chloride dispersion may reach 2500 m from the slurry dump sites.

We detected soil sectors salified by brines in the first mine enterprise's zone of operation on territory of the "Gornyak [Miner]" sovkhoz (sect. 13, 250 m SW of the salt dumps), the "Svoboda [Freedom]" sovkhoz (E of the dumps), and on sectors near farm buildings of the villages of Tomilova Gora and Teslino; also in the second mine enterprise's zone of operations on the "Luch Kommunizma [Communism's Beam]" kolkhoz (sect. 3, 6, and others situated N of the salt dumps) and on the "Gornyak" sovkhoz (sect. 12 S of the salt dumps).

All of the sectors indicated above were salified in 1966-67. Presently, the entry of salts into these fields is no longer observed, as a result of measures taken by the combine; this naturally has an effect on the chlorine content of the soil.

We present the dynamics of chlorine ion content on sectors with a varying sub-surface water level as an example (in sect. 3, the sub-surface water level is above 2 m, and in sect. 13, sub-surface water lies at a depth of 5-6 m).

It may be seen from Table 2 that, in spite of the five-year period since the soil became salty, the chlorine ion content in section 3 is very high in all seasons, the maximum being observed in the warmest and driest summer period. The over-all content of salts in the 0-10 cm layer at this time reached 3.63% in 1969, 2.00% in 1970, and 1.44% in 1971. This means that in warm weather, the soil turns into true 'solonchak' since, according to the classification of soils made by Kovda et al. (1960) or by Bazilevich and Pankova (1968), soils with a dry residue content (the sum of the salts) greater than 0.7-0.8% belong to 'solonchaks' with chloride salification. Such a phenomenon is conditioned by the close proximity of mineral-forming sub-surface water, from which the chlorides are drawn up by capillary action to the surface soil, building up in the uppermost layer.

Table 2

Chlorine Ion Content, mg·equiv/100g soil

depth, cm.	1969			1970			1971		
	spr.	sum.	fall	spr.	sum.	fall	spr.	sum.	fall
section 3									
0—10	not determined	56,84	8,73	4,86	29,77	3.86	12,08	21,22	8,89
10—20		8.47	9,97	3.18	7.34	7,88	7.57	8,61	12,00
20—30		8,96	8.18	2.57	6.62	8,47	6.51	8.03	8,00
30—40		4,81	6,24	2,14	4.86	6,71	4.26	5,84	4.72
40—50		1,85	2,67	1,22	2.84	4,55	3.90	4,74	3,59
70—80		0,31	1,93	0,96	1.17	—	1,75	2.19	3,60
90—100		0,36	1,26	0,58	0,39	—	1;29	1,59	2,23
140—150		0,48	—	—	—	—	—	—	—
sub-surface water g/l		0,50	4.35	2.20	3,52	5,83	4,12	5,54	8,58
from depth, cm.		195	140	115	147	70	115	140	98
section 13									
0—10	0,46	3,06	4,30	0,15	0,62	0,13	0,10	0,30	0,07
10—20	0,58	3.82	6.05	0,15	0.54	0,16	0,13	0,20	0,08
20—30	0.88	5,48	6,65	0,19	1.53	0.28	0,22	0,26	0,10
30—40	0,99	5,76	6,00	0,25	2,76	0.92	0,46	0,73	0,10
40—50	1,18	5,95	5.99	0.28	3,31	2.21	0,74	0,05	0,10
70—80	5,68	7,24	6,14	2,20	4,44	3.52	1,03	0,07	0,35
90—100	6,25	5,90	4.88	3,07	4,01	3,10	2,70	0,12	0,27
140—150	1,57	1,41	1,53	1,88	2,22	1,76	2,22	0,10	0,16

In the salified sectors where the sub-surface water level is deep (section 13), salt content diminishes yearly as a result of the salt being washed down to great depths, from which it is unable to rise into the upper soil layers. Consequently, if salts no longer enter from outside, the desalination process will take place intensely on those sectors where the sub-surface water is at great depth, even though in individual seasons, a certain displacement of salts into the upper layers is still noted.

It is necessary to note that in spite of the intensity of desalination, this process goes on for a rather long time. The sector we examined (section 13) was salified by brine as early as 1966, and it was only six years later that the desalination had reached a near-normal state. ...

Observations of vegetation sprouting in the operations zone of the combine showed that many species suffer from toxic substances disposed of by the mine enterprises. We established that gaseous pollutants of the concentration plant works contain not only salt dust, but also phototoxic gases such as SO_2 and HCl. Analogous phenomena are also observed where potassium fertilizer is produced in the DDR. As the investigations of Ewert and Dässler (1967) have shown, gaseous wastes cause damage to stands of green vegetation primarily within a radius somewhat greater than one km from the polution source, whereas the influence of SO_2 was observed by them up to 4 km.

Agricultural crops, primarily potatoes, which are extremely sensitive to excessive amounts of chlorides, also suffer from gaseous pollutants. In 1969, potatoes planted at a distance of 500-1000 m NW of the first mine site (sect. 17 and 20), over an area of 31.5 hectares, showed pronounced signs of inhibited growth.

Other agricultural crops also suffer from air polution. In 1970, barley, and in 1971, winter wheat, sewn over the same sector, also showed signs of inhibition.

Analogous examples of the harmful effects of gaseous pollutants are observed near other mine sites. Thus, for example, near the third mine site, eighteen hectares of winter rye died in 1971 as a result of emissions from the stacks of the concentration plant works, and losses were caused to the winter wheat and clover crops and to vegetable garden crops.

Table 3

Content of Cl, Na, and K ions in Snow Water, mg/l

mine site	distance from concentration plant works, m	1970			1971		
		Cl'	Na'	K'	Cl'	Na'	K'
1-st	500 north	4,86	2,10	1,70	8.20	3,30	2,60
	1000	4,43	1,70	1,40	7,19	2,90	2,10
	2000	—	—	—	5,53	2,00	1,20
	3000	—	—	—	3,58	0,90	0,90
2-nd	500 north	8,64	2,70	5,60	8,29	2,10	4,07
	1000	5,39	1,60	3,90	3,33	0,80	0,90
	2000	—	—	—	3,33	0,90	1,10
	3000	—	—	—	3,33	0,70	0,70
1-st	500 northwest	6,06	2,50	2,70	10,92	2,80	15,80
	1000	5,39	2,10	2,00	6,63	2,60	2,90
	2000	—	—	—	5,40	1,80	2,70
	3000	—	—	—	4,96	1,30	2,50

The influence of the salt excess is felt most strongly on those sectors salified by brines. In 1969, all the corn shoots perished in the center of a salified sector where the amount of chlorides was at a maximum; in connection with this, bare sectors were formed with numerous deep cracks in the surface of a soil lacking any type of vegetation. The chloride content decreased in proportion to the distance from the center of the sector towards the periphery, and vegetation continued to grow, but was strongly inhibited. In growth, it lagged behind normally developed vegetation by 3-4 times; it had blue-violet stripes on the leaves, and marginal desication was noted.

Oats and quack grass (Agropyrum), which normally develop on almost the entire salified sector, with the exception of small spots of 'solonchak', were most resistant to chloride excess in the soil.

Thus, potassium industry wastes cause considerable damage to a majority of the agricultural crops and to several species of fruit trees, resulting in a decrease in the harvest yield and a deterioration in its quality.

In February 1970-71, we selected snow samples in which the number of Cl, Na, and K ions were determined (Table 3), with the aim of determining more exactly the boundaries of salt distribution from the stacks of the concentration plant works.

From the data presented, it may be seen that the Cl ion content declines noticeably in proportion to the distance from the mining sites. The greatest quantity was observed at a distance of 500-1000 m from the concentration plant works. Besides that, it was established that the Cl ion content within a radius of up to 2000 m from the pollution source exceeds the mean content of the European part of the USSR, equal to 2-3 mg/l, by two or more times (Drozdova, et al., 1964). An exceptionally large number of chlorine ions was detected in 1971 in snow water to the north-west of the first mine site; the chlorine content at a distance of 500 m reached 19.92 mg/l, which is 6-8 times the norm.

Data from an analysis of the snow water confirms the results of soil investigations which attest to increased chloride content in the upper soil layers within a 1000 m radius of a mine site. In addition, the K' content in the soils and the snow water is almost always higher than that for Na', which proves that they enter from the smokestacks of the concentration plant works.

Along with investigations on soils and vegetation, we studied the influence of wastes from the "Beloruskaliy" Combine on the pollution of surface waters. Samples of sewage from a storm/surface-water sewage system from the first mine site and of water from the Sluch' River, into which the industrial effluents are discharged, were taken three times a year for analysis. River water samples were taken at two points: approximately ten km above the place of sewage discharge (near the village of Pogost) and at the same distance downstream (near the settlement of Starobin).

Table 4

General Mineralization and Chlorine Ion Content in Effluent Waters and in Water from the Sluch' River, g/l--(numerator-dry residue; denominator-Cl').

site of water sample collection	1969	1970			1971		
	fall	spr.	sum.	fall	spr.	sum.	fall
indust. effluent from first mine site	$\frac{30,585}{17,227}$	$\frac{36.930}{21,888}$	$\frac{1,228}{0.503}$	$\frac{145,0}{82,250}$	$\frac{0.404}{0,128}$	$\frac{241.6}{135,926}$	$\frac{64,020}{36,274}$
Sluch' River near Pogost	$\frac{0,246}{0,015}$	$\frac{0.286}{0,033}$	$\frac{0.270}{0,024}$	$\frac{0.255}{0,026}$	$\frac{0.203}{0,043}$	$\frac{0.200}{0,021}$	$\frac{0,324}{0,053}$
Sluch' River near Starobin	$\frac{0,454}{0,140}$	$\frac{0,307}{0,118}$	$\frac{0,464}{0,178}$	$\frac{0.583}{0,225}$	$\frac{0.416}{0,142}$	$\frac{0.430}{0,160}$	$\frac{0,632}{0,264}$

The data from Table 4 attest to the fact that liquid production wastes, the mineralization of which varies sharply according to weather conditions, at times reaching 241.6 g/l, are discharged into the Sluch' River; that is, either strongly salified waters or brine is discharged into the river in practice (Jakush, 1970), according to the generally accepted classification of natural waters.

The chloride content in the waters of the Sluch' River below the production zone of the first and third mine sites was on the average about 14 mg/l for 1959-63, according to material from the Belorussian SSR's Hydrology and Meteorology Service. In 1966, after the first mine site had been in operation three years, the chlorine content in the river water was 55.8 mg/l (Zakharenkov, 1968), i.e. it had increased four times.

The average chlorine ion content in the water near the village of Pogost (according to our data) was equal to 0.031 mg/l, i.e. twice as high as the original reading, while in the water near the settlement of Starobin, it was 0.175 mg/l, which exceeds the initial value by 12.5 times. Thus, the pollution of the Sluch' River by chlorides entering from the first mine site grows constantly. When the third mine site is in operation, water pollution takes place even near the village of Pogost.

CONCLUSIONS

1. Salification of soils in the region of the Soligorsk "Beloruskaliy" Combine is conditioned by the action of gaseous wastes from the concentration plant works and by penetration of brines formed from salt dumps and thaw and rain water.

2. Gaseous pollution from the concentration plant works exert a toxic action on vegetation, causing a decline in harvest yield of agricultural crops. Potatoes suffer most of all, and among the fruit stands, apple and cherry trees suffer heavily. Oats, from among the cultivated plants, and quack grass (Agropyrum), a weed, are relatively resistant to gaseous pollutants.

3. The negative effect zone of gaseous polutants is most sharply apparent within a one-kilometer radius of the mine site.

4. As a result of the periodic discharge of the industrial effluents of a storm/surface sewage system, the chloride content in the Soligorsk reservoir grew sharply. Even at a distance of about 10 km below the place of sewage discharge, the chlorine ion content exceeds the initial magnitude by 12.5 times.

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THEORETICAL COMPOSITION OF SALINE WATER SATURATED WITH ANHYDRITE

It is probable that most of the ground water in the Rustler Formation that is not brine is saturated with either gypsum or anhydrite. Such water has little utility, and is generally used only for watering livestock. Humans can also tolerate such water, but it is not recommended as a permanent domestic water supply. If large amounts of such water are available and soil conditions are right it can be used for irrigation, but it has marginal utility for this purpose.

The solubility of anhydrite is about 2.09 grams per litre; therefore, a saturated solution contains about 600 milligrams per litre of calcium and about 1500 milligrams per litre of sulfate. The concentration of either of these constituents can exceed these values, however, and it is not uncommon to obtain sulfate concentrations of more than 2,000 milligrams per litre in groundwater supplies in or near this area. Nearly all chemical analyses given by Cooper (1962, Table 3) for water samples from wells tapping the Rustler Formation show saturation or near-saturation with gypsum or anhydrite.

THEORETICAL COMPOSITION OF BRINES SATURATED WITH HALITE, SYLVITE AND POTASH ORES

Chemical analyses of many brines and saline waters in the Clayton Basin and Nash Draw are given in Tables (2) and (3). In most cases the brines have complex origins, composed generally of mixtures of natural and artificial brines along with storm runoff and saline ground water. The chemistry of brines is very complex, imperfectly understood, and difficult to treat quantitatively. When brines are mixed with other brines or saline water some constituents may precipitate while others may be dissolved from the geologic environment due to the more corrosive characteristics of the mixture.

The chemical composition of a brine is a function of the amount the geochemical activity of the various constituents in the geologic environment. Some constituents are more inert than others and if these are present in concentrations so low that they will not form precipitates, their concentrations can be used to study the history of the brine. In the studies at Malaga Bend by the U. S. Geological Survey the boron, bromide, and even the potassium concentrations of the inflowing brine to Anderson Lake have been used to calculate the evaporation. Because of its geochemical affinity for clay, the potassium ion would not be a good choice ordinarily for such studies, but in cases when the clays are about saturated with potassium its concentration can be useful. The potassium concentrations of natural waters in New Mexico rarely exceed 20 milligrams per litre, but in this area natural concentrations are much greater. For example, the brine from well USGS 8 table (2) has been analyzed periodically for many years, and until the casing of this well was damaged a few years ago the concentrations were always about 4,500 milligrams per litre. At present the concentration is less probably because of dilution of fresher water through the damaged casing. Most readers will find the study of the composition of brines in tables (2) and (3) easier if data are given for comparison. At normal room temperature the solubility of halite and sylvite are about equal to 350 grams per litre therefore, a brine saturated with pure halite would have a composition of approximately 138,000 milligrams per liter of sodium and 212,000 milligrams per litre of chloride. A brine saturated with pure sylvite would have a compositon of 184,000 milligrams per liter of potassium and 166,000 milligrams per litre of chloride.

For the purpose of comparison, brines saturated with potash ores are considered to have concentrations of sodium, potassium, and chloride intermediate to the values given for pure halite and pure sylvite. Some notion of these concentrations are given by analyses of three ore samples collected from refineries in the area. The assays of these ores are given in the following table.

Assay (percent)

Ore	Sodium	Potassium	Chloride	Sulfate	Bromide	Boron
Duval	14.0	30.4	51.7	0.24	0.24	0.0009
Amax	16.3	31.0	53.5	.56	.11	.017
PCA	20.6	23.1	53.1		.28	.0006

Assuming a solubility of about 350 milligrams per litre the saturated brines composed of these ores would have approximately the following compositions (milligrams per litre).

Ore	Sodium	Potassium	Chloride	Bromide	Boron
Duval	49,000	106,000	181,000	850	3
Amax	57,000	108,000	187,000	394	59
PCA	72,000	81,000	186,000	983	2

The assays of these ores were computed from analyses made by a laboratory of the U. S. Geological Survey. Most constituents are about correct but the bromide concentrations appear to be to great (Adams, 1969, p. 80).

Boron and bromide are minor constituents in potash ores. At places within the Delaware Basin boron concentrations of brines are moderately great (Kunkler, 1972, p. 209) and it was hoped that the brines in Nash Draw and the Clayton Basin would have boron concentrations great enough to be useful for future studies of brine hydrology. A study of these concentrations shows that they vary widely with the source of brine, with ore specimens, and with reservoir locations, hence studies using their concentrations probably will not be fruitful.

The bromide concentrations may be more useful if more accurate determinations can be made. This ion is moderately inert in most geological environments, and it is noted that the concentration of bromide is related roughly and directly to the potassium concentration. This is because the crystal lattice of the sylvite crystal can more easily accomodate the bromide ion than does the crystal lattice of the halite crystal, hence in a ore of sylvite and halite the sylvite will tend to have about 10 times greater bromide concentrations than the halite (Adams, S. S., 1969, p. 28). For this reason brines with anomolously large bromide concentrations should be suspected of having or once having large potassium concentrations.

It is to be noted also that the ratios of potassium and bromide concentration in the brines from Well USGS 8 and Anderson Lake are nearly equal. The greater concentrations in the reservoir brine are due to evaporation and the ratios of these constituents can be used, under favorable conditions to estimate the evaporation and leakage.

Vegetation Species

Alkali Sacaton - Sporobolus airoides; Torr.[1]

Allthorn - Koeberlinia spinosa; Zucc.

Bahia - Bahia pedato; Gray.

Black grama - Bouteloua eriopida Torr.

Bladder pod - Lesquerella fendleri; (Gray) Wats.

Broom Snakeweed - Gutierrezia sarothrae; (Pursh) Britt. & Rusby.

Bush muhly - Muhlenbergia porteri; Scribn.

Cane bluestem - Andropogon saccharoides; Swartz.

Catclaw - Acacia constricta; Benth.

Chinaberry - Melia spp.

Cottonwood - Populus spp.

Creosote bush - Larrea tridentata (DC.) Coville

Croton - Croton texensis (Klotzsch) Muell. Arg.

Desert baileya - Baileya multiradiata; Harv. & Gray.

Desert Verbena - Verbena spp.

Dropseed - Sparobolus spp.

Fall witch grass - Leptoloma cognatum; (Schult.) Chase.

Feather peabush - Dalea formosa; Torr.

Fluff grass - Tridens pulchellus

Four-wing saltbush - Atriplex canescens; (Pursh) Nutt.

Gyp grama - Bouteloua breviseta

Hackberry - Celtis reticulata

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[1] Scientific Names follow those in Kearney & Peebles, Arizona Flora. University of California Press, Berkeley and Los Angeles, 1951.

Halls panicum - Panicum hallii; Vasey.

Harvards three-awn - Aristida barbata; Fourn.

Hooded windmill grass - Chloris virgata; Swartz.

Javelina bush - Microbamnus ericoides; Gray.

Lemon weed - Pectis papposa; Harv. & Gray.

Little leaf sumac - Rhus trilobata; Nutt.

Mesa dropseed - Sporobolus flexuosus; (Thurb.) Rydb.

Mesquite - Prosopis juliflora; Swartz, D.S. Var. glandulosa.

Pepperweed - Lepidium spp. (Torr. Cockerall).

Pickleweed - Allenrolfea occidintalis; (Wats) Kuntze.

Plains bristlegrass - Setaria macrostachya. H.B.K.

Prickle pear cactus - Opuntia spp.

Ragweed - Ambrosia aptera; DC.

Rayless goldenrod - Aplopappus heterophyllus; (Gray) Blake.

Ring muhly - Muhlenbergia Torreyi; (Kunth) Hitchc.

Salt cedar - Tamarix pentandra; Pall.

Sand sage - Artemisia filifolia; Torr.

Scribners panicum - Panicum scribnerianum; Nash.

Sixweek grama - Boutelou; garbata

Spectacle pod - Dithyrea wislizeni; Engelm.

Squawbush - Lycium pallidum

Stipa - Stipa comata; Trin. & Rupr.

Sunflower - Helianthus annuus; L.

Tasajillo cactus - Opuntia leptocaulis; DC.

Vine mesquite - Panicum obtusum; H.B.K.

Yucca - Yucca spp.

APPENDIX B-2

Aquatic Wildlife Species

Bird Species

Status (Federal List)

*Endangered
**Threatened
***Status Undetermined

Status (State List)

+Endangered

Common Names	Scientific Names
Western Grebe	(Aechmophorus occidentalis)
Eared Grebe	(Podiceps caspicus)
Pied-Billed Grebe	(Podilymbus podiceps)
Snow Goose	(Chen hyperborea)
Mallard	(Anas platyrhynchos)
Pintail	(Anas acuta)
Gadwall	(Anas strepera)
American Widgeon	(Mareca americana)
Blue-Winged Teal	(Anas discors)
Cinnamon Teal	(Anas cyanoptera)
Green-Winged Teal	(Anas corolinensis)
Shoveler	(Spatula clypeata)
Ruddy Duck	(Oxyura jamaicensis)
Common Merganser	(Mergus merganser)
Coot	(Fulica americana)
American Avocet	(Recurvirostra americana)
Black-Necked Stilt	(Himantopus mexicanus)
Black-Bellied Plover	(Squatarola squatarola)
***Snowy Plover	(Charadrius alexandrinus)
Marbled Godwit	(Limosa fedoa)
Semi-palmated Plover	(Charadrius semipalmatus)
Spotted Sandpiper	(Actitis macularia)
White-rumped Sandpiper	(Erolia fuscicollis)
Solitary Sandpiper	(Tringa solitaria)
Willet	(Catoptrophorus semipalmatus)
Baird's Sandpiper	(Erolia bairdii)
Least Sandpiper	(Erolia minutilla)
Stilt Sandpiper	(Micropalama himantopus)
Pectoral Sandpiper	(Erolia melanotos)
Wilson's Phalarope	(Steganopus tricolor)
Northern Phalarope	(Lobipes lobatus)
Common Snipe	(Capella gallinago)
Forster's Tern	(Hirundo forsteri)
Least Tern	(Sterna albifrons)
Black Tern	(Chlidonias niger)
Belted Kingfisher	(Magaceryle alcyon)

AQUATIC REPTILES AND AMPHIBIAN SPECIES

Status (Federal List)

*Endangered
**Threatened
***Status Undetermined

Status (State List)

+Endangered

Common Name	Scientific Name
Tiger Salamander	(Ambystoma tigrinum)
Barking Frog	(Eleutherodactylus augusti)
Couch's Spadefoot Toad	(Scaphiopus couchi)
Western Spadefoot Toad	(Scaphiopus hammondi)
Plains Spadefoot Toad	(Scaphiopus bombifrons)
Great Plains Toad	(Bufo cognatus)
Texas Toad	(Bufo speciosus)
Green Toad	(Bufo debilis)
Red-Spotted Toad	(Bufo punctatus)
Leopard Frog	(Rana pipiens)
Bull Frog	(Rana catesbeiana)

AQUATIC FISH SPECIES

+ Pupfish	(Cyprinodon sp.)

Terrestrial Wildlife Species

Bird Species

Status (Federal List)

*Endangered
**Threatened
***Status Undetermined

Status (State List)

+Endangered

Common Names	Scientific Names
***Mountain Plover	(Eupoda montana)
Black-Bellied Plover	(Squatarola squatarola)
Killdeer	(Charadrius vociferus)
***Long-billed Curlew	(Numenius americanus)
Upland Plover	(Bartramia longicauda)
Turkey Vulture	(Cathartes aura)
Marsh Hawk	(Circus cyaneus)
Rough Legged Hawk	(Buteo lagopus)
***Ferruginous Hawk	(Buteo regalis)
Red-tailed Hawk	(Buteo jamaicensis)
Swainson's Hawk	(Buteo swainsoni)
Harris Hawk	(Parabuteo unicinctus)
Golden Eagle	(Aquila chrysaetos)
*Bald Eagle	(Haliaeetus leucocephalus)
**Prairie Falcon	(Falco mexicanus)
Sparrow Hawk	(Falco sparverius)
*Peregrine Falcon	(Falco eregrinus)
**Lesser Prairie Chicken	(Tympanuchus pallidicinctus)
Scaled Quail	(Callipepla squamata)
Gambel's Quail	(Lophortyx gambelii)
Bobwhite Quail	(Colinus virginianus)
Domestic Pigeon	(Columba livia)
White-Winged Dove	(Zenaida asiatica)
Mourning Dove	(Zenadura macroura)
Road-runner	(Geococcyx californianus)
Great Horned Owl	(Bubo virginianus)
***Burrowing Owl	(Speotyto cunicularia)
Short-eared Owl	(Asio flammeus)
Common Nighthawk	(Chordeiles minor)
Lesser Nighthawk	(Chordeiles acutipennis)
Yellow-Shafted Flicker	(Colaptes auratus)
Red-Shafted Flicker	(Colaptes cafer)
Ladder-backed Woodpecker	(Dendrocopos scalaris)
Western Kingbird	(Tyrannus verticalis)

Terrestrial Wildlife Species (Bird Species)

Scissor-tailed Flycatcher	(Muscivora forticata)
Ash-throated Flycatcher	(Myiarchus cinerascens)
Say's Phoebe	(Saynornis saya)
Gray Flycatcher	(Empidonax wrightii)
Horned Lark	(Eremophila alpestris)
Barn Swallow	(Hirundo rustica)
Common Raven	(Corvus corax)
White-necked Raven	(Corvus cryptoleucus)
Bewick's Wren	(Thryomanes bewickii)
Cactus Wren	(Campylorhynchus brunneicapillum)
Long-billed Marsh Wren	(Telmatodytes palustris)
Mockingbird	(Mimus polyglottos)
Catbird	(Dumetella carolinensis)
Brown Thrasher	(Toxostoma rufum)
Curve-billed Thrasher	(Toxostoma curvirostre)
Crissal Thrasher	(Toxostoma dorsale)
Sage Thrasher	(Oreoscoptes montanus)
Robin	(Turdus migratorius)
Eastern Bluebird	(Sialia sialis)
Western Bluebird	(Sialia mexicana)
Mountain Bluebird	(Sialia currucoides)
Sprague's Pipit	(Anthus spragueii)
Phainopepla	(Phainopepla nitens)
Loggerhead Shrike	(Lanius ludovicianus)
Starling	(Sturnus vulgaris)
Bell's Vireo	(Vireo bellii)
Black-throated Blue Warbler	(Dendroica caerulescens)
House Sparrow	(Passer domesticus)
Eastern Meadow Lark	(Sturnella magna)
Western Meadow Lark	(Sturnella neglecta)
Yellow-headed Blackbird	(Xanthocephalus xanthocephalus)
Red-Winged Blackbird	(Agelaius phoeniceus)
Brewer's Blackbird	(Euphagus cyanocephalus)
Brown-headed Cow bird	(Molothrus ater)
Boat-Tailed Grackle	(Cassidix mexicanus)
Common Grackle	(Quiscalus quiscula)
Bullock's Oriole	(Icterus bullockii)
Cardinal	(Richmondena cardinalis)
Pyrrhuloxia	(Pyrrhuloxia sinuata)
Blue Grosbeak	(Guiraca caerulea)
House Finch	(Carpodacus mexicanus)
Rufous-sided Towhee	(Pipilo erythrophthalmus)
Brown Towhee	(Pipilo fucus)
Lark Bunting	(Calamospiza melanocorys)
Savannah Sparrow	(Passerculus sandwichensis)
Lark Sparrow	(Chondestes grammacus)
Vesper Sparrow	(Pooecetes gramineus)
Cassin's Sparrow	(Aimophila cassinii)
Black-Throated Sparrow	(Amphispiza bilineata)

Terrestrial Wildlife Species (Bird Species)

Sage Sparrow	(Amphispiza belli)
Tree Sparrow	(Spizella arborea)
Clay-Colored Sparrow	(Spizella pallida)
Field Sparrow	(Spizella pusilla)
Brewer's Sparrow	(Spizella breweri)
White-Crowned Sparrow	(Zonotrichia leucophrys)
Golden-Crowned Sparrow	(Zonotrichis atricapilla)
White-Throated Sparrow	(Zonotrichia albicollis)
Song Sparrow	(Melospiza melodia)
+McCown's Longspur	(Rhynchophanes mccownii)
Chestnut-Collared Longspur	(Calcarius ornatus)
Dickcissel	(Spiza americana)

APPENDIX B-3 cont.

TERRESTRIAL REPTILES AND AMPHIBIAN SPECIES

Status (Federal List)

*Endangered
**Threatened
***Status Undetermined

Status (State List)

+Endangered

Common Name	Scientific Name
Western Box Turtle	(Terrapene ornata)
Lesser Earless Lizard	(Holbrookia maculata)
Greater Earless Lizard	(Holbrookia texana)
Leopard Lizard	(Grotaphytus wislizenii)
Eastern Fence Lizard	(Sceloporus undulatus)
Side-Blotched Lizard	(Uta stansburiana)
Tree Lizard	(Urosaurus ornatus)
Texas Horned Lizard	(Phrynosoma cornutum)
Short-Horned Lizard	(Phrynosoma douglassi)
Round-Tailed Horned Lizard	(Phrynosoma Modestum)
Great Plains Skink	(Eumeces obsoletus)
Many-Lined Skink	(Eumeces multivirgatus)
Little Striped Whiptail	(Cnemidophorus inornatus)
Texas Spotted Whiptail	(Cnemidophorus gularis)
Texas Blind Snake	(Leptotyphlops dulcis)
Western Hognose Snake	(Heterodon nasicus)
Coachwhip	(Masticophis flagellum)
Striped Whipsnake	(Masticophis taeniatus)
Glossy Snake	(Arizona elegans)
Bull Snake	(Pituophis melanoleucus)
Long-Nosed Snake	(Rhinocheilus lecontei)
Common Garter Snake	(Thamnophis sirtalis)
Ground Snake	(Sonora episcopa)
Western Hook-Nosed Snake	(Ficimia cana)
Plains Black-Headed Snake	(Tantilla nigriceps)
Western Black-Headed Snake	(Tantilla planiceps)
Night Snake	(Hypsiglena torquata)
Trans-Pecos Rat Snake	(Elaphe subocularis)
Black-Necked Garter Snake	(Thamnophis cyrtopsis)
Pygmy Rattlesnake	(Sistrurus catenatus)
Western Diamondback Rattlesnake	(Crotalus atrox)

TERRESTRIAL MAMMAL SPECIES

Status (Federal List)

*Endangered
**Threatened
***Status Undetermined

Status (State List)

+Endangered

Common Names	Scientific Names
Gray Shrew	(Notiosorex crawfordi)
Cave Myotis (Bat)	(Myotis velifer)
Long-Legged Myotis (Bat)	(Myotis volans)
California Myotis (Bat)	(Myotis californicus)
Western Pipistrel (Bat)	(Pipistrellus hesperus)
Pallid Bat	(Antrozous pallidus)
Mexican Freetail Bat	(Tadarida brasiliensis)
Big Freetail Bat	(Tadarida molossa)
Ring Tail	(Bassariscus astutus)
Badger	(Taxidea tasus)
Hognose Skunk	(Conepatus leuconotus)
Coyote	(Canis latrans)
Kit Fox	(Vulpes macrotis)
Gray Fox	(Urocyon cinereoargenteus)
Bobcat	(Lynx rufus)
Thirteen-Lined Ground Squirrel	(Citellus tridecemlineatus)
Spotted Ground Squirrel	(Citellus spilosoma)
Mexican Ground Squirrel	(Citellus mexicanus)
Valley Pocket Gopher	(Thomomys bottae)
Mexican Pocket Gopher	(Cratogeomys castanops)
Merriam Pocket Mouse	(Perognathus merriami)
Silky Pocket Mouse	(Perognathus flavus)
Desert Pocket Mouse	(Perognathus penicillatus)
Nelson Pocket Mouse	(Perognathus nelsoni)
Hispid Pocket Mouse	(Perognathus hispidus)
Bannertail Kangaroo Rat	(Dipodomys spectabilis)
Ord Kangaroo Rat	(Dipodomys ordi)
Southern Grass Hopper Mouse	(Onychomys torridus)
Plains Harvest Mouse	(Reithrodentomys montanus)
Cactus Mouse	(Peromyscus eremicus)
White-Footed Mouse	(Peromyscus leucopus)
Deer Mouse	(Peromyscus maniculatus)
Brush Mouse	(Peromyscus boylei)
Whitethroat Woodrat (Packrat)	(Neotoma albigula)
Southern Plains Woodrat (Packrat)	(Neotoma micropus)

APPENDIX B-3 cont.

TERRESTRIAL MAMMAL SPECIES (cont)

Norway Rat	(Rattus norvegicus)
House Mouse	(Mus musculus)
Blacktail Jackrabbit	(Lepus californicus)
Desert Cottontail	(Sylvilagus floridanus)
Mule Deer	(Odocoileus hemionus)
White-tailed Deer (no recent sightings)	(Odocoileus virginianus)
Antelope	(Antilocapra americana)

USE OF THE POTASH STUDY AREA BY THREATENED ANIMALS

Species	Season of Use
Mountain plover	Spring, summer, fall (nests)
Snowy plower	Summer (nests)
Long-billed curlow	Migration (possibly winter)
Ferruginous hawk	Winter
Bald eagle	Migration (possibly winter)
Prairie falcon	Winter
Peregrine falcon	Migration (possibly winter)
Lesser prairie chicken	Yearlong (nests)
Burrowing owl	Yearlong (nests)
McCown's longspur	Fall-Winter

APPENDIX C 1

Carlsbad Potash Study Area - Land Area, Total Population, Urban and Rural Distribution, Population Density and Percentage Change 1960 - 1970

AREA	TOTAL AREA [1]		TOTAL POPULATION		URBAN POPULATION 1970 [3]		RURAL POPULATION 1970 [3]		1970 Pop./ Sq.Mile	PERCENTAGE CHANGE 1960 to 1970		
	Sq. Miles	Acres	1960 [2]	1970 [3]	No.	%	No.	%		Total	Urban	Rural
Study Area	8,574	5,487,360	104,212	90,673	71,795	79.2	18,878	20.8	10.6	- 13.0	- 10.3	- 21.8
Eddy Co.	4,180	2,675,200	50,783	41,119	31,612	76.9	9,507	23.1	9.8	- 19.0	- 15.8	- 28.2
Lea Co.	4,394	2,812,160	53,429	49,554	40,183	81.1	9,371	18.9	11.3	- 7.3	- 5.5	- 14.1
SENMEDD*	26,166	16,746,300	206,581	182,665	136,896	74.9	45,769	25.1	7.0	- 11.6	- 5.3	- 26.2
New Mexico	121,666	77,866,240	951,023	1,016,000	708,775	69.8	307,225	30.2	8.4	6.8	13.1	- 5.3

[1] Source - New Mexico Association of Counties, May 1971, Total Area includes inland water area and land area.

[2] Source - Bureau of Census

[3] Source - Bureau of Census, PC(1)A33, Number of Inhabitants, New Mexico, Table 9.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 2

Carlsbad Potash Study Area - Population and Population Per Square Mile 1960, 1970, and 1974[1]

AREA	POPULATION			POPULATION PER SQUARE MILE		
	1960	1970	1974	1960	1970	1974
Study Area	104,212	90,673	90,800	12.2	10.6	10.6
Eddy Co.	50,783	41,119	40,400	12.2	9.9	9.7
Lea Co.	53,429	49,554	50,400	12.2	11.3	11.5
SENMEDD*	206,581	182,665	189,200	7.9	6.9	7.2
New Mexico	951,023	1,017,055	1,122,500	7.8	8.4	9.2

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[1] Bureau of Business Research, University of New Mexico, Population Estimates: July 1974, Business Information Series No. 56, May 1975, Page 5.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln and Otero Counties (area covered in New Mexico Planning and Development District No. 6).

APPENDIX C 3

Carlsbad Potash Study Area - Estimated Population, Percent Change, and Net Migration, Mid-Year 1970-1974 [1]

AREA	Mid-Year Population*					Components of Change, 1970-1972	
	1970	1971	1972	1973	1974	Percentage Change	Net Migration**
Study Area	90,700	90,500	90,300	90,000	90,800	0.1	- 3,870
Eddy Co.	41,100	40,900	40,900	41,200	40,400	- 1.7	- 2,010
Lea Co.	49,600	49,600	49,400	48,800	50,400	1.6	- 1,860
SENMEDD***	183,000	185,700	185,800	186,300	189,200	3.4	- 2,450
New Mexico	1,019,100	1,044,800	1,066,000	1,099,200	1,122,500	10.1	49,260

[1] Bureau of Business Research, University of New Mexico, Population Estimates: July 1974, Business Information Series No. 56, May 1975, Table 1, Page 4.

*Rounded to nearest hundred.

**Rounded to nearest ten.

***Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area covered is New Mexico Planning and Development District No. 6).

APPENDIX C 4

Carlsbad Potash Study Area - Population Distribution by Age and Sex, 1970

AREA	TOTAL POPULATION	PERCENT					PERCENT	
		0-14 Years	15-24 Years	25-44 Years	45-64 Years	65 and Over	Male	Female
Study Area	90,673	31.2	17.2	24.0	20.7	6.9	49.2	50.8
Eddy Co.	41,119	30.5	17.3	21.5	21.8	8.9	48.7	51.3
Lea Co.	49,554	31.8	17.1	26.0	19.7	5.4	49.6	50.4
SENMEDD*	182,665	32.3	17.6	24.0	19.1	7.0	49.6	50.4
New Mexico	1,016,000	33.3	18.5	23.7	17.5	7.0	49.3	50.7

Source - Bureau of Census, Census of Population, 1970.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area covers New Mexico Planning and Development District No. 6).

APPENDIX C 5

Carlsbad Potash Study Area - Population - Ethnic Distribution

AREA	TOTAL	WHITE TOTAL		SPANISH SURNAME		OTHER		NEGRO		INDIAN		OTHER	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Study Area	90,673	86,333	95.2	18,757	20.7	67,576	74.5	3,509	3.9	258	0.3	573	0.6
Eddy Co.	41,119	39,925	97.1	12,555	30.5	27,370	66.6	899	2.2	83	0.2	212	0.5
Lea Co.	49,554	46,408	93.7	6,202	12.5	40,206	81.2	2,610	5.3	175	0.3	361	0.7
SENMEDD*	182,665	171,918	94.1	43,162	23.6	128,756	70.5	6,818	3.8	2,563	1.4	1,366	0.7
New Mexico	1,016,000	915,815	90.1	407,286	40.1	508,529	50.0	19,555	1.9	72,788	7.2	7,842	0.8

Source - Bureau of Census, Census of Population 1970

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 6

Carlsbad Potash Study Area - Educational Level of Persons 25 Years and Over, 1970

AREA	TOTAL POPULATION	YEAR OF SCHOOL COMPLETED										MEDIAN YEARS COMPLETED		HIGH SCHOOL GRADUATE	
	25 Years and Over	0 Years	Percent Total	1-4 Years	Percent Total	5-8 Years	Percent Total	9-12 Total	Percent Total	13 and Over Years	Percent Total	Male	Female	Male Percent	Female Percent
Study Area	46,970	1,234	2.6	2,571	5.5	8,923	19.0	25,097	53.4	9,145	19.5	11.7	12.0	48.1	50.3
Eddy Co.	21,499	813	3.8	1,477	6.9	4,357	20.3	10,692	49.7	4,160	19.3	11.6	11.9	47.5	49.3
Lea Co.	25,471	421	1.7	1,094	4.3	4,566	17.9	14,405	56.5	4,985	19.6	11.8	12.0	48.7	51.3
SENMEDD*	91,655	2,036	2.2	4,781	5.2	17,281	18.9	47,194	51.5	20,363	22.2	12.1	12.0	54.2	53.0
New Mexico	489,623	16,263	3.3	27,369	5.6	91,816	18.7	230,539	47.1	123,704	25.3	12.2	12.1	27.1	32.6

Source - Bureau of Census, Census of Population, 1970.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 7

Carlsbad Potash Study Area - Population
Actual 1960 and 1970, and Projected to 2000

AREA	POPULATION - ACTUAL [1] 1960	1970	POPULATION - PROJECTED [3] 1980	1990	2000
Study Area	104,212	90,673	151,100	185,600	244,500
Eddy Co.	50,783	41,119	66,500	80,600	104,200
Lea Co.	53,429	49,554	84,600	105,000	140,300
SENMEDD*	206,581	182,665	318,200	396,400	522,400
New Mexico	951,023	1,016,000	1,630,000	2,111,000	2,788,000

[1] Bureau of Census, Census of Population 1970.

[2] New Mexico Bureau of Business Research, Projections of the Population of New Mexico and its counties to the year 2000, 1975. (medium projections).

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 8

Carlsbad Potash Study Area - Employment by Major Industry, 1970

AREA	TOTAL EMPLOYMENT	MANUFACTURING	MINING	CONSTRUCTION	TRANSPORTATION PUBLIC UTILITIES AND COMMUNICATIONS	WHOLESALE AND RETAIL TRADE	FINANCE INSURANCE AND REAL ESTATE	SERVICE	GOVERNMENT	ALL OTHER NON-AGRICULTURE	ALL AGRICULTURE
Study Area	34,407	1,332	7,777	1,222	2,754	5,893	868	3,615	4,302	4,186	2,458
Eddy Co.	14,862	641	3,231	413	703	2,337	392	1,898	2,082	1,947	1,218
Lea Co.	19,545	691	4,546	809	2,051	3,556	476	1,717	2,220	2,239	1,240
SENMEDD*	65,545	3,930	8,213	2,239	4,197	10,835	1,882	8,558	12,201	8,523	4,876
New Mexico	350,200	21,200	16,900	15,900	20,100	61,000	12,400	53,500	89,100	39,900	20,200

Source - SENMEDD, Overall Economic Development Program, 1973, Phase 2.

Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 9

Carlsbad Potash Study Area - Percentage of Total Employment

AREA	TOTAL EMPLOYMENT	MANUFACTURING	MINING	CONSTRUCTION	TRANSPORTATION PUBLIC UTILITIES AND COMMUNICATIONS	WHOLESALE AND RETAIL TRADE	FINANCE INSURANCE AND REAL ESTATE	SERVICE	GOVERNMENT	ALL OTHER NON-AGRICULTURE	ALL AGRICULTURE
Study Area	100	3.9	22.6	3.6	8.0	17.1	2.5	10.5	12.5	12.2	7.1
Eddy Co.	100	4.3	21.8	2.8	4.7	15.7	2.6	12.8	14.0	13.1	8.2
Lea Co.	100	3.5	23.3	4.1	10.5	18.2	2.4	8.8	11.4	11.5	6.3
SENMEDD*	100	6.0	12.6	3.4	6.4	16.6	2.9	13.1	18.6	13.0	7.5
New Mexico	100	6.1	4.8	4.5	5.7	17.4	3.5	15.3	25.4	11.4	5.8

Source - SENMEDD, Overall Economic Development Program, 1973, Phase 2.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6)

Carlsbad Potash Study Area - Labor Force Participation Rate, 16 Years Old and Over, 1970

AREA	POPULATION 16 YEARS AND OVER			LABOR FORCE			PARTICIPATION RATE (Percentage)		
	Total	Male	Female	Total	Male	Female	Total	Male	Female
Study Area	60,080	29,088	30,992	33,948	22,979	10,969	56.5	79.0	35.4
Eddy Co.	27,557	13,143	14,414	14,928	9,864	5,064	54.2	75.1	35.1
Lea Co.	32,523	15,945	16,578	19,020	13,115	5,905	58.5	82.3	35.6
SENMEDD*	121,212	58,311	62,901	68,814	45,971	22,843	56.8	78.9	36.3
New Mexico	652,417	316,417	336,000	358,237	234,249	123,988	54.9	74.0	36.9

Source - U. S. Bureau of Census, Census of Population, 1970

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area - Labor Force Participation Rate, 14 Years Old and Over, 1970

AREA	POPULATION 14 YEARS AND OVER*			LABOR FORCE**	PARTICIPATION RATE
	Total	Male	Female	Total	Percent
Study Area	64,619	31,363	33,256	36,204	56.0
Eddy Co.	29,564	14,157	15,407	15,812	53.5
Lea Co.	35,055	17,206	17,849	20,392	58.2
SENMEDD***	127,602	62,808	64,794	69,181	54.2
New Mexico	701,153	341,352	359,801	373,900	53.3

*Source - New Mexico Employment Security Commission

**Source - Labor Information Series Annual Average, 1970

***Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area - Estimated
Unemployment by Education, 1970

AREA	UNEMPLOYED	PERCENT UNEMPLOYED SCHOOL YEARS COMPLETED			
	Total	0-7 years	8-11 years	12 years	12 or more years
Study Area	1,797	11.1	41.3	36.1	11.4
Eddy Co.	950	12.2	38.5	38.8	10.5
Lea Co.	847	10.0	44.4	33.1	12.5
SENMEDD*	3,726	10.4	39.3	38.0	12.3
New Mexico	23,700				

Source - SENMEDD Overall Economic Development Program, 1973, Phase 2.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area
Unemployment Trends, 1960 - 1970

AREA	1960 UNEMPLOYMENT		1970 UNEMPLOYMENT		CHANGE IN TOTAL	AVERAGE ANNUAL
	Number	Rate	Number	Rate	Percent	Change
Study Area	1,833	4.7	1,797	5.1	-1.9	-3.6
Eddy Co.	897	4.8	950	6.0	5.9	5.3
Lea Co.	936	4.6	847	4.2	-9.5	-8.9
SENMEDD*	3,534	4.5	3,726	5.4	5.4	19.2
New Mexico	18,196	6.0	23,700	6.3	30.2	550.4

Source - SENMEDD, Overall Economic Development Program, 1973, Phase 2.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area - Medium Projections of
Employment and Participation Rates
1980, 1990 and 2000

AREA	Employment 1980	Employment 1990	Employment 2000	Participation Rate 1980	Participation Rate 1990	Participation Rate 2000
Study Area	55,880	67,780	90,510	37.0	36.5	37.0
Eddy Co.	24,560	29,430	38,580	36.9	36.5	37.0
Lea Co.	31,320	38,350	51,930	37.0	36.5	37.0
SENMEDD*	117,550	144,700	192,770	36.9	36.5	36.9
New Mexico	573,000	745,200	1,010,600	35.2	35.3	36.4

Source - New Mexico Bureau of Business Research, Projections of the Population of New Mexico and its Counties to the Year 2000, 1965.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area - Income Data Showing
Median and Mean Family Income and Per Capita Income in 1969

AREA	TOTAL FAMILIES	MEDIAN INCOME	MEAN INCOME	PER CAPITA INCOME
Study Area	23,668	8,287	9,210	3,294
Eddy Co.	10,535	7,870	8,851	3,114
Lea Co.	13,133	8,703	9,568	3,444
SENMEDD*	46,150	7,685	9,072	3,260
New Mexico	242,740	7,849	9,193	2,877

Source - U. S. Bureau of Census, 1970 Census of Population.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 16

Carlsbad Potash Study Area - Number and Percent of Families Under Poverty Level, 1960 and 1969

AREA	1960			1969		
	TOTAL NUMBER OF FAMILIES	NUMBER OF FAMILIES UNDER POVERTY LEVEL	PERCENT OF FAMILIES UNDER POVERTY LEVEL	TOTAL NUMBER OF FAMILIES	NUMBER OF FAMILIES UNDER POVERTY LEVEL	PERCENT OF FAMILIES UNDER POVERTY LEVEL
Study Area	26,232	4,174	15.9	23,668	3,513	14.8
Eddy Co.	12,443	2,282	18.4	10,535	1,877	17.8
Lea Co.	13,789	1,892	13.7	13,133	1,636	12.5
SENMEDD*	50,897	17,623	34.6	46,150	7,301	15.8
New Mexico	222,000	54,900	24.7	242,740	44,906	18.5

Source - U. S. Bureau of Census, Census of Population 1960 and 1970.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study - Total Personal Income and
Per Capita Income, 1959, 1965, and 1969

AREA	TOTAL PERSONAL INCOME (000)			PER CAPITA INCOME		
	1959	1965	1969	1959	1965	1969
Study Area	214,300	267,200	301,700	2,128	2,680	3,294
Eddy Co.	99,400	125,500	130,100	2,025	2,508	3,114
Lea Co.	114,900	141,700	171,600	2,226	2,853	3,444
SENMEDD*	416,500	524,500	599,900	2,087	2,582	3,260
New Mexico	1,758,900	2,263,100	2,878,600	1,914	2,242	2,877

Source - New Mexico Bureau of Business Research, New Mexico Studies in Business and Economics, Income and Employment in New Mexico, Selected Years, 1929-1969, No. 22, 1973.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area - Total Personal Income and Per Capita Income

AREA	TOTAL PERSONAL INCOME (Millions of Dollars)				PER CAPITA INCOME (Dollars)		
	1969*	1972	1973	% Increase 1972-1973	1969	1972	1973
Study Area	302	317	360	13.6	3,294	3,468	4,008
Eddy Co.	130	139	160	15.1	3,114	3,369	3,883
Lea Co.	172	178	200	12.4	3,444	3,567	4,132
SENMEDD**	544	648	742	14.5	3,260	3,483	4,023
New Mexico	2,879	3,779	4,262	12.8	2,877	3,511	3,877

Source - U. S. Department of Commerce, Survey of Current Business.

*1969 Data from Bureau of Business Research.

**Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development No. 6).

Carlsbad Potash Study Area - Sources of Personal Income, 1969 - Amount Derived from Principal Economic Activities

AREA	TOTAL PERSONAL INCOME (000's)	TOTAL EARNINGS (000's)	AGRICULTURE (000's)	MINING (000's)	GOVERNMENT (000's)	OTHER ECONOMIC ACTIVITIES (000's)
Study Area	301,700	249,024	23,369	71,117	33,110	121,430
Eddy Co.	130,100	104,331	11,014	29,213	17,461	46,643
Lea Co.	171,600	144,693	12,355	41,904	15,649	74,787
SENMEDD*	600,139	497,720	51,775	75,307 [1]	133,504	237,134 [2]
New Mexico	2,878,600	2,330,400	155,400	154,300	697,300	1,323,400

Source - New Mexico Bureau of Business Research, New Mexico Studies in Business and Economics, Income and Employment in New Mexico, Selected Years, 1929-1969, No. 22, 1973.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (also covers New Mexico Planning and Development District No. 6).

[1] Mining data withheld for some counties

[2] Data withheld included in other activities

Carlsbad Potash Study Area
Percent of Personal Income, 1969, Derived from Principal Economic Activities

AREA	PERCENT DERIVED FROM PRINCIPAL ECONOMIC ACTIVITIES			PERCENT DERIVED FROM OTHER ECONOMIC ACTIVITIES
	Agriculture	Mining	Government	
Study Area	8	24	11	57
	8	22	13	57
	7	24	9	60
SENMEDD*	9	13	22	56
New Mexico	5	5	24	66

Source - New Mexico Bureau of Business Research, New Mexico Studies in Business and Economics, Income and Employment in New Mexico, Selected Years, 1929-1969, No. 22, 1973.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

Carlsbad Potash Study Area - Per Capita Income
as a Percentage of Per Capita Income for New Mexico,
1959, 1965, and 1969

AREA	1959 (%)	1965 (%)	1969 (%)
Study Area	111	120	115
Eddy Co.	106	112	108
Lea Co.	116	127	120
SENMEDD*	109	115	102
New Mexico	100	100	100

Source - Developed from Per Capita Income Data, Table.

*Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (area also covers New Mexico Planning and Development District No. 6).

APPENDIX C 22

Carlsbad Potash Study Area - Occupancy And Vacancy Characteristics, 1970.

Area	Total Population in Year-Round Housing Units	Total Year-Round Housing Unit*	Population Per Occupied Housing Unit**	Owner Occupied Unit	Percent Owner Occupied Units	Rental Occupied Units	Percent Rental Occupied Units	Total Vacant	Percent Vacant
Study Area	89,782	32,044	3.3	19,098	59.6	8,425	26.3	4,521	14.1
Eddy Co.	40,466	14,937	2.6	8,657	58.0	3,870	26.0	2,410	16.0
Lea Co.	49,316	17,107	1.2	10,441	61.0	4,555	26.6	2,111	12.4
SENMEDD***	178,532	65,485	3.3	36,379	55.6	17,692	27.0	11,414	17.4
New Mexico	988,853	322,294	3.4	192,236	59.7	97,153	30.1	32,905	10.2

Source - U. S. Bureau of Census, Detailed Housing Characteristics New Mexico, 1970 Census of Housing, Tables 32, 60.

* Year-round units exclude vacant units intended for seasonal occupancy and vacant units held for migratory units.

** Computed by dividing total population in year-round housing units by sum of owner and renter occupied units.

*** Southeastern New Mexico Economic Development District consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties (also covers New Mexico Planning and Development District No. 6)

APPENDIX C 23

Carlsbad Potash Study Area - Structural Characteristics of Housing by Single Family Units, Multi-Family Units and Mobile Homes, 1970

Area	Total Year-Round Housing Units	Single-Family Units	Percent Single-Family Units	Multi-Family Units	Percent Multi-Family Units	Mobile Homes	Percent Mobile Homes
Study Area	32,044	28,535	89.0	2,141	6.7	1,368	4.3
Eddy Co.	14,937	13,467	90.2	1,096	7.3	374	2.5
Lea Co.	17,107	15,068	88.1	1,045	6.1	994	5.8
SENMEDD*	65,485	56,678	86.6	5,299	8.1	3,508	5.3
New Mexico	322,294	262,388	81.4	40,995	12.7	18,911	5.9

Source - U. S. Bureau of Census, Detailed Housing Characteristics New Mexico, 1970 Census of Housing, Tables 35 and 62.

* Southeastern New Mexico Economic Development District (Same as New Mexico Planning and Development District No. 6) consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 24

Carlsbad Potash Study Area - Age of Year-Round
Housing Units Showing Year Structure Built.

		Year Structure Built							
Area	Total Year-Round Units	1939 or Earlier	Percent 1939	1940-49	Percent 1940-49	1950-59	Percent 1950-59	1960 - March 1970	Percent 1960- March 1970
Study Area	32,044	4,834	15.1	8,389	26.2	12,223	38.1	6,598	20.6
Eddy Co.	14,937	2,868	19.2	4,430	29.6	5,016	33.6	2,623	17.6
Lea Co.	17,107	1,966	11.5	3,959	23.2	7,207	42.1	3,975	23.2
SENMEDD*	65,485	11,389	17.4	13,999	21.4	24,402	37.3	15,695	23.9
New Mexico	322,294	72,279	22.4	56,273	17.5	100,758	31.3	92,984	28.8

Source - U. S. Bureau of Census, Detailed Housing Characteristics New Mexico, *1970, Census of Housing*, Tables 35 and 62.

* Southeastern New Mexico Economic Development District (same as New Mexico Planning and Development District No. 6) consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 25

Carlsbad Potash Study Area, 1970 Utilization and Plumbing Characteristics of Year-Round Housing Units

Area	Total Year - Round Units	Lacking Some or All Plumbing Facilities	Percentage Lacking Some or all Plumbing Facilities	Persons/Room Greater Than 1.01	Percentage Persons/ Room Greater Than 1.01
Study Area	32,044	1,170	3.7	3,196	10.0
Eddy Co.	14,937	752	5.0	1,461	9.8
Lea Co.	17,107	418	2.4	1,735	10.1
SENMEDD*	65,485	2,617	4.0	6,336	9.7
New Mexico	322,294	32,369	10.0	44,319	13.8

Source - U. S. Bureau of Census, Detailed Housing Characteristics New Mexico, 1970 Census of Housing, Tables 32, 33.

* Southeastern New Mexico Economic Development District (same as New Mexico Planning and Development District No. 6) consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 26

Carlsbad Potash Study Area, 1970 Value of Specified Owner Occupied Housing.*

Area	Total Owner Occupied Year - Round Units	Median	Less Than $5,000	$5,000 - $9,999	$10,000 - $14,999	$15,000 - $19,999	$20,000 - $24,999	$25,000 - $34,999	$35,000 - or more
Study Area	16,454	$10,800	2,190	5,060	5,089	1,996	945	733	441
Eddy Co.	7,623	10,600	1,057	2,402	2,449	866	360	266	223
Lea Co.	8,831	11,000	1,133	2,658	2,640	1,130	585	467	218
SENMEDD**	30,514	11,000	4,004	8,858	9,072	4,294	1,979	1,365	441
New Mexico	157,170	13,100	19,406	31,671	43,224	29,540	13,928	12,090	7,311

Source - U. S. Bureau of Census, Detailed Housing Characteristics New Mexico, 1970 Census of Housing, Tables 34 and 61.

* Limited to one-family homes on less than 10 acres and no business on property.

** Southeastern New Mexico Economic Development District (same as New Mexico Planning and Development District No. 6) consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 27

Carlsbad Potash Study Area, 1970 Contract Rent of Specified Renter Occupied Rental Housing Units

Area	Total Specified Renter Occupied Units	Contract Rent								
		Median ($)	Less Than $30	$30 - $39	$40 - $59	$60 - $79	$80 - $99	$100 - $149	$150 or more	No Cash
Study Area	7,801	60	589	697	2,074	2,131	802	613	146	749
Eddy Co.	3,550	57	171	413	1,173	820	240	250	65	418
Lea Co.	4,251	64	418	284	901	1,311	562	363	81	331
SENMEDD	16,350	69	778	1,176	3,623	3,430	1,724	2,379	562	2,678
New Mexico	91,285	72	3,601	5,115	17,633	18,406	12,015	15,527	5,275	13,713

Source - U. S. Bureau of Census, Detailed Housing Characteristics New Mexico, 1970 Census of Housing, Tables 34 and 61.

* Southeastern New Mexico Economic Development District (same as New Mexico Planning and Development No. 6) consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 28

Carlsbad Potash Study Area, Public School Facilities,
Showing Enrollment, Teachers, Pupil Teacher Ratio,
Average Annual Expenditures, and Expenditure Per Pupil, 1970-1971

Area	Pupil Enrollment		Teacher Number		Pupil-Teacher Ratio		Average Annual Expenditure	Expenditure Per Pupil
	Elem.	Sec.	Elem.	Sec.	Elem.	Sec.	Elem. - Sec. Combined	Elem. - Sec. Combined
Study Area	16,537	8,100	696	365	23.76	22.19	$ 17,252,079	$ 700
Eddy Co.	7,416	3,726	293	159	25.31	23.43	7,388,014	663
Lea Co.	9,121	4,374	403	206	22.63	21.23	9,864,065	731
SENMEDD*	34,518	15,475	1,440	690	23.97	22.43	$ 34,241,769	$ 685

Source - State of New Mexico Department of Finance and Administration, Public School Finance Division

*Southeastern New Mexico Economic Development District (Same as New Mexico Planning and Development District) consists of Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 29

Carlsbad Potash Study Area, Public School Facilities Funding, 1970-1971

Area	Total Funds	Source of Funds Local	 State	 Federal	Local as Percent of Total
Study Area	$ 17,700,602	$ 5,850,311	$ 11,635,980	$ 214,311	33.05
Eddy Co.	7,423,812	2,000,559	5,319,707	103,546	26.95
Lea Co.	10,276,790	3,849,752	6,316,273	110,765	37.46
SENMEDD*	$ 34,757,810	$ 7,883,050	$ 24,613,259	$ 2,261,501	22.68

Source __ State of New Mexico Department of Finance and Administration, Public School Finance Division

*Southeastern New Mexico Economic Development District (same as New Mexico Planning and Development District No. 6) consists fo Chaves, Eddy, Lea, Lincoln, and Otero Counties.

APPENDIX C 30

Carlsbad Potash Study Area,
Other Educational Facilities, 1970-1971

Area	Number of Pupils	Parochial Schools (Elementary) Number of Pupils	Pupil-Teacher Ratio	Higher Education Enrollment Junior College	Four Year College and University	Vocational Training	Other Enrollment Adult Programs
Study Area	320	15	21.0	2,870	513	731	---
Eddy Co.	213	9	23.7	400	---	---	---
Lea Co.	107	6	17.8	2,470	513	731	---
SENMEDD*	602	29	20.8	4,701	513	1,071	233

Source ___ New Mexico Personnel Directory and Educational Institutions

*Southeastern New Mexico Economic Development District (same as New Mexico Planning and Development District No. 6) consists of Chaves, Eddy, Lea, Lincoln, and Otero counties.

APPENDIX C 31

Carlsbad Potash Study Area,
Public School Enrollment by Grade, 1973-1974

Area	Kindergarten*	Handicapped	1st Grade	2nd Grade	3rd Grade	4th Grade	5th Grade	6th Grade	7th Grade	8th Grade	9th Grade	10th Grade	11th Grade	12th Grade	Advance Grades	Totals
Study Area	833	311	1,775	1,644	1,783	1,875	1,818	1,986	1,961	1,947	1,980	1,971	1,860	1,670	18	22,599
Eddy Co.	333	173	782	732	805	860	771	882	896	932	879	908	861	793	5	10,279
Artesia	109	73	243	246	267	282	279	295	316	308	302	319	278	256	--	3,464
Carlsbad	195	100	500	441	499	522	451	536	534	569	534	589	583	537	5	6,400
Loving	29	---	39	45	39	56	41	51	46	55	43	---	---	---	--	415
Lea Co.	500	138	993	912	978	1,015	1,047	1,104	1,065	1,015	1,101	1,063	999	877	13	12,320
Eunice	39	10	50	52	37	53	59	65	62	59	79	74	53	55	--	699
Hobbs	268	82	616	507	611	619	646	679	648	627	670	652	602	535	13	7,507
Jal	49	---	45	59	60	58	59	66	79	76	93	62	91	58	--	806
Lovington	117	46	250	245	241	242	250	258	241	214	231	240	219	197	--	2,874
Tatum	27	---	32	49	29	43	33	36	35	39	37	35	34	32	--	434

Source ___ State of New Mexico, Annual Statistical Report of the Superintendent of Public Instruction, 1973-1974 School Year, page 7.

*Kindergarten not included in totals

Carlsbad Potash Study Area,
Public School Average Daily Membership, 1974-1975

Area	School District	Average Daily Membership
Study Area		21,833
Eddy Co.		9,958
	Artesia	3,322
	Carlsbad	6,268
	Loving	368
Lea Co.		11,875
	Eunice	686
	Hobbs	7,155
	Jal	805
	Lovington	2,793
	Tatum	436
New Mexico		273,564

Source: Statistical Services ___ New Mexico State Department of Education, February 4, 1975.

MAILING LIST

A. A. U. W.
Mrs. Wallace Dow
1316 Westridge
887-1527

Altrusa Club*
Marie McCloskey
1007 N. Alameda
885-4721

A. A. R. P.*
Charles Mumford
1306 Bryan Circle
885-5770

American Business Womens Association
Betty Calicoat
205 S. Ash
885-4490

American Legion
Edwin Thomas
601 W. Orchard Lane
885-4258

American Legion Auxiliary*
Lilly Robison
607 N. Olive
885-8506

Art Appreciation*
Mrs. George Eddy
1612 N. Guadalupe
885-4474

Assistance League of Carlsbad
Margaret Tregoning
1301 Doepp
885-8759

B. & P. W.
Opal Bird
2308 Avenue A.
885-5875

Beta RHO Chapter
Epsilon Sigma Alpha
(Cystic Fibrosis Info Center)
Lilly Frintz
1017 Birch Lane
885-9526

Boy Scouts*
George Crump
District Chairman Chisium Trail
906 Alamosa
885-2226

Boys Club Auxiliary
Mrs. Helen Hague
Senior Recreation Center
1112 N. Mesa
885-6487

Camp Fire Girls
Rosemary Andrews
1308 Beta
885-3737

Carlsbad Area Art Association
Marjorie O'Hearn
212 S. Mesa
887-1533

Carlsbad Ladies Newcomers
Mrs. Jean Hill
816 N. Alamosa
885-9031

Carlsbad Medical Center Auxiliary
Mary Lunn Forehand
102 E. Cherry Lane
885-4580

Carlsbad Nile Club
Mrs. O. H. Smith
1305 Chico Drive
885-3868

Catholic Daughters of America*
Helen Havlik
214 N. Elm
885-6500

Cavern City Kiwanis*
David Emery
1501 Park Street
885-6032

Chamber of Commerce*
Robert D. Brown
610 W. Riverside
887-3119

D. A. R.*
Mrs. Thomas Kearns
1131 Tracy Place
885-6159

D. A. V. Ladies Unit 13
Buena Busby
1206 N. Country Club
885-9394

D. A. V. # 13
Bob Pemberton
1029 N. Halagueno
885-3803

D. A. V. Chapter 30
Junior Smart
4207 Texas
885-9877

D. A. V. Ladies Unit 30
Mrs. Elmer Ebright
110 E. 9th
885-5247

Democratec Women
Mrs. Wallace Bowen
1030 N. Pate
885-8169

Does*
Mrs. J. B. Vaughn
1106 Normandy
885-9706

Downtown Lions
George Lair
1306 N. Country Club
885-3518

Eddy County Homemakers Council*
Mis. Jim Ogden
Rt. 1 Box 65
745-3369 Loving, NM 88256

Eddy County Sheriffs Possettes
Mrs. Don Kidd
118 W. Cherry Lane
887-5204

B. P. O. Elks Lodge #1558
Bud Linneweh
1401 Westridge
887-2642

Epworth Methodist Women (WSCS)
Mrs. Pat Griswold
1114 N. Canal
885-8141

Evening Lions
Jim Lewis
1117 W. Bonbright
885-5074

Girl Scouts
Joyce Bryant
402 Rosedale
887-5271

Buena Vista Grandmothers Club
Camilla Perkowski
1414 Bryan Circle
885-5311

Green Thumb Graden Club
Mrs. M. B. Carey
1417 S. Country Club
887-5356

Guadalupe Grotto
Jerry Trout
2915 Piedras Road
885-2288

Heights Lions
Tony Rodriquez
1505 W. Howard
885-6847

Jaycees
Allan Hinds
1104 W. Edwards
885-5746

Kiwanis
John Penn
1310 W. Thomas
885-2444

Knife & Fork Club
Dr. Wesley Drury
307 W. Alameda
885-6787

Lambda (CHI) Omega National Sorority
New Mexico Gamma Chapter
Vernell Barrick
2411 Bonita
885-2579

New Mexico Alpha Chapter
Mrs. Joe Pulice
706 N. Hickory
885-5859

New Mexico Beta Chapter
Mrs. Robert Soderberg
1120 Tracy Place
887-5398

Lions Auxiliary
Mrs. Sidney Bernard
1309 Gamma
885-8320

Loyal Order of Moose
W. E. Johnson
107 W. Francis
885-4906

Licensed Practical Nurses
Clara Austin
2203 Georgia
885-8521

Masons*
Robert Swayze
1418 S. Country Club
885-3606

Ministerial Alliance
R. D. Murray
1306 Alvarado
885-8789

New Mexico 145
Helen Peters
208 W. McKay
885-5707

Navy Mothers Club Chapter 932*
Doris McGinnis, Commander
2402 Bonita
885-4756

New Mexico Heart Association
Mrs. Maxine Felton
1306 W. Stevens
885-4191

New Mexico Nurses Association
Wilma Harper
1715 N. Canal
885-8563

Eddy County Medical Assistance Society
Donna Best
612 Lakeside Drive
885-3698

Odd Fellows (IOOF)
Jesse Strong
1031 N. Pate
885-4028

Theta RHO (IOOF)
Elizabeth Martinez
317 Etter
887-2553

P. E. O. Chapter A*
Mrs. Jim Odgen
Rt. 1 Box 65
745-3369 Loving

P. E. O. Chapter Y
Mrs. Glade C. Hogsett
805 W. Riverside
885-2600

Pecos Valley Mental Health Council*
Tony Sylvester
1022 N. Alameda
885-9598

Order of Eastern Star
Georgia Farris
1310 W. Ural
885-8373

Pilot Club*
Mrs. Charles Curry
915 N. Alameda
885-5087

Redbekah Lodeg # 13*
Neva Morton
901 Pate
885-8738

Republican Women
Patsy McCargish
721 Standpipe Road
885-6948

Roadrunner Collectors Club
L. T. Hardesty
209 N. 3rd
887-1462

Rotary Club
Dr. Robert Murray
1007 N. Shore
885-3552

School Administration*
Tom Hanson, Superintendent
103 West Hagerman
887-2821

Senior Social Club*
Madge Austin
1029 N. Francis
885-8406

Toastmasters*
Bob Wilkinson
1515 Bryan Circle
885-6786

V. F. W.
Larry Potter
105A S. Lake
887-3406

V. F. W. Auxiliary
Clara Haley
406 W. Church
887-1856

Waaimes*
Mrs. Jack Hunt
1509 S. Country Club
887-2590

Welcome Wagon
Nancy Jo Miller
1304 W. Ural
885-5365

Woman's Division of Chamber of Commerce*
Darlene Moutray
1605 W. Riverside
887-3454

United Methodist Women
Mrs. Wilma Parchman
1212 W. Thomas
885-6962

Woman's Club of Carlsbad*
Mrs. Robert Clark
604 Lakeside Drive
885-4484

Radio KBAD*
Darrell Swayze
714 N. Canyon
885-2151

4-H Clubs
Carlsbad 4-H
Dark Canyon 4-H
Lone Valley 4-H

Standpipe 4-H
Bill Thompson
Associate County Agent
P. O. Box 100
Courthouse Rm. 107
885-6656
885-3274

Extension Clubs
Happy Circle Extension
Happy Homemakers Extension
Mrs. Elton Kern, County Home Agent
P. O. Box 100, Courthouse Rm. 107
885-6656
885-3274

Carlsbad Sportsman Club
Jime Runkel
112 S. Ash
887-3920

United Steel Workers Auxiliary*
Catherine Bowen
1030 N. Pate
885-8169

John A. McComb
Southwestern Rep. Sierra Club
2014 E. Broadway Rm. 212
Tucson, Arizona 85719

S. E. New Mexico Audobon Soc.*
P. O. Box 1553
Roswell, N. M.

Rich Breisen
P. O. Box 3594 Boles Sta.
Alamogrodo, NM 88310

Dave Foreman
P. O. Box 157
Glenwood, NM 88039

Economic and Industrial Commission
408 W. Texas Av.
Artesia, NM 88210

Artesia Chamber of Commerce
408 W. Texas Av.
Artesia, NM 88210

B. P. O. Elks Lodge
322 Quay Ave.
Artesia, NM 88210

Masonic Temple
315 W. Richardson Av.
Artesia, NM 88210

Moose Lodge of Artesia 2152
1602 S. 1
Artesia, NM 88210

Pecos Valley Baptist Association
Booker Bldg.
Artesia, NM 88210

United Veterans
402 Hermosa Dr.
Artesia, NM 88210

Woman's Club
1776 N. Turner
Hobbs, NM 88240

Fraternal Order of Eagles
1200 E. White
Hobbs, NM 88240

Moose Lodge No. 2084
2920 W. Maryland
Hobbs, NM 88240

N. M. State Environmental Improvement Agency
205 N. Linam
Hobbs, NM 88240

Independent Order of Odd Fellows
210 W. Taylor
Hobbs, NM 88240

American Legion
319 E. Dunnam
Hobbs, NM 88240

V. F. W. Post 3274*
1800 N. Turner
Hobbs, NM 88240

Glen E. Gavin*
Hobbs Chamber of Commerce
P. O. Box 1136
206 N. Turner
Hobbs, NM 88240

Environmentalists
805 Linam
Hobbs, NM 88240

Masonic Lodge N. 65
528 S. 5th
Jal, NM 88252

American Legion
3rd.
Jal, NM 88252

County Manager, Lea County
County Courthouse
Lovington, NM 88260

Lovington Lodge, No. 46 AF&AM
106 W. Washington Ave.
Lovington, NM 88260

Lovington Chamber of Commerce
P. O. Box 1347
Lovington, NM 88260

County Extension Service*
Lea County
County Courthouse
Lovington, NM 88260

American Legion*
Lovington, NM 88260

Housing Authority
Eunice, NM 88231

Eunice Lodge No. 67
1710 Main
Eunice, NM 88231

American Legion Post No. 45
Texas Ave.
Eunice, NM 88231

Eunice Chamber of Commerce
1021 Main
Eunice, NM 88231

Eastern Star Chapter No. 66
1710 Main
Eunice, NM 88231

* Response Received

APPENDIX C 34

All Fertilizer: Total Use and Primary Nutrient Use, United States, 1960-74[1]

Year Ended, June 30	Total Use	Primary Nutrient Use: N	Primary Nutrient Use: Available P_2O_5	Primary Nutrient Use: K_2O	Primary Nutrient Use: Total	Primary Nutrient Use: Index
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1967=100
1960	24,887	2,738.0	2,572.4	2,153.3	7,463.7	53.4
1961	25,567	3,030.8	2,645.1	2,168.5	7,844.4	56.1
1962	26,615	3,370.0	2,807.0	2,270.5	8,447.5	60.5
1963	28,844	3,929.1	3,072.9	2,503.4	9,505.4	68.0
1964	30,681	4,352.8	3,377.8	2,729.7	10,460.3	74.9
1965	31,836	4,638.5	3,512.2	2,834.5	10,985.3	78.6
1966	34,532	5,326.3	3,897.1	3,221.2	12,444.7	89.1
1967	37,082	6,027.1	4,304.1	3,641.8	13,973.6	100.0
1968	38,743	6,787.6	4,453.3	3,792.6	15,033.5	107.6
1969	38,949	6,957.6	4,665.6	3,891.6	15,514.8	111.0
1970	39,591	7,459.2	4,573.9	4,035.7	16,068.8	115.0
1971	41,118	8,133.6	4,803.4	4,231.4	17,168.4	122.9
1972	41,206	8,016.0	4,863.7	4,326.8	17,212.8	123.2
1973[2]	43,288	8,295.2	5,085.2	4,648.7	18,029.1	129.1
1974[3]	46,997	9,123.8	5,070.6	5,085.7	19,280.1	138.0

1/ Includes Puerto Rico.
2/ Revised.
3/ Preliminary.

APPENDIX C 35

Imports of Specified Potash Materials, K_2O Equivalent, into the United States, Years Ended June 30, 1973-74, By Country of Origin

Country	1973: Muriate of Potash	1973: Sulfates	1974: Muriate of Potash	1974: Sulfates
	1,000 T.	1,000 T.	1,000 T.	1,000 T.
Brazil	7	-	-	-
Brazzaville	12	-	-	-
Canada	3,036	-	3,985	(1/)
Chile	2	-	-	-
France	2	11	6	10
Germany (W.)	-	16	-	23
Israel	72	-	44	-
Netherlands	4	-	-	-
Spain	11	-	-	-
Zaire	3	-	-	-
Belgium	-	-	-	4
Other Countries	-	-	-	-
U.S.S.R.			25	-
Total	3,150	27	4,060	37

1/ Less than 100 tons. - None reported.

Archaeology Legislation

The following is a brief summary of relevant legislation involving cultural values:

Antiquities Act of 1906--This basic legislation provides that the appropriation, excavation, injury or destruction of cultural values on federal lands is punishable by fine and/or imprisonment. It establishes the principle that government, acting for the people, should not only protect, but also work towards preservation of cultural values. Cultural values on federal lands may be dealt with only under the aegis of a permit issued through the Office of the Consulting Archaeologist. (McGimsey 1972:111)

Historic Sites Act of 1935--This act makes it national policy to preserve significant cultural values and has served as the basis for the National Register of Historic Sites. This register lists those sites so far identified as having national historic significance.

Reservoir Salvage Act of 1960--This act provides that an attempt shall be made to recover cultural values affected by the construction of a dam by any federal agency or federally licensed agency. It is a specific application of the Historic Sites Act of 1935. (McGimsey 1972:117)

Historic Preservation Act of 1966--It was this act that expanded the National Register of Historic Sites to include those of local, State and regional as well as national significance. It establishes the State Historic Preservation Officer as a liaison for the program and also established the Advisory Council on Historic Preservation.

Section 106 of this act is of importance:

> The head of any Federal agency having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking in any State and head of any Federal department or independent agency having authority to license any undertaking shall prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license,..., take into account the effect of the undertaking on any district, site, building structure, or object that is included in the National Register.

Executive Order 11593--This reinforces the Historic Preservation Act of 1966 and directs all federal agencies to make sure that federally owned properties that might qualify for nomination to the National Register is not inadvertently transferred, sold, demolished or substantially altered.

Historical and Archaeological Data Preservation Act of 1974--(Moss-Bennett Bill or P.L. 93-291). This law is salvage oriented and site specific and provides for the salvage of significant data from cultural resources subject to irreparable loss or destruction and for the survey necessary for the determination to be made as to whether or not a site should be salvaged.

These laws and orders form the basis for the requirements that proposed surface disturbing actions have archaeological clearances which identify endangered cultural values.

The Historic Sites Act, Reservoir Salvage Act, Historic Preservation Act and E.O. 11593 direct the federal agencies to preserve cultural value of significance. The agencies have interpreted this to mean that in those locations where exact data on cultural values is not available a survey will be performed to identify whether or not National Register quality values are involved. If such values are involved, a 106 Statement of Effect must be prepared in conjunction with the State Historic Preservation Officer and submitted to the Advisory Council for comment. If values not of National Register quality are encountered the agencies and companies are still bound by the provisions of the Antiquities Act and any mitigation other than avoidance must be performed under an Antiquities Permit.

(b) Claims shall be filed directly with the local field office of the Bureau or Office of the Department out of whose activities the accident or incident occurred, if known; or if not known with the Associate Solicitor, Territories, Wildlife and Claims, Department of the Interior, Washington, D.C. 20240.

(c) Upon receipt of a claim, the time and date of receipt shall be recorded. The claim shall be forwarded with the investigative file immediately to the Regional or Field Solicitor or the Associate Solicitor, Territories, Wildlife and Claims, as appropriate, for determination.

§ 22.4 Denial of claims.

Denial of a claim shall be communicated as provided by § 14.9 of the Regulations (23 CFR Part 14).

§ 22.5 Payment of claims.

(a) When an award of $2,500 or less is made, the voucher signed by the claimant shall be transmitted for payment to the appropriate Bureau or Office of the Department. When an award over $2,500 is made, transmittal for payment will be made as prescribed by § 14.10 of the Regulations (28 CFR Part 14).

(b) Prior to payment appropriate releases shall be obtained as provided in said section.

APPENDIX A—PROCEDURES FOR FILING CLAIMS UNDER THE FEDERAL TORT CLAIMS ACT ACCRUING ON AND BEFORE JANUARY 17, 1967.

A. *Purpose.* The purpose of this Appendix A to Part 22 is to establish procedures for the filing of claims under the Federal Tort Claims Act (in part, 28 U.S.C. 2401(b), 2671–2680), accruing on and before January 17, 1967.

B. *Provisions of law.* 1. Section 2672 of Title 28, United States Code, provides:

"(a) The head of each Federal agency, or his designee for the purpose, acting on behalf of the United States, may consider, ascertain, adjust, determine, and settle any claim for money damages of $2,500 or less against the United States accruing on and after January 1, 1945, for injury or loss of property or personal injury or death caused by the negligent or wrongful act or omission of any employee of the Government while acting within the scope of his office or employment, under circumstances where the United States, if a private person, would be liable to the claimant in accordance with the law of the place where the act or omission occurred.

"(b) Subject to the provisions of this title relating to civil actions on tort claims against the United States, any such award or determination shall be final and conclusive on all officers of the Government, except when procured by means of fraud.

"(c) Any award made pursuant to this section, and any award, compromise, or settlement made by the Attorney General pursuant to section 2677 of this title, shall be paid by the head of the Federal agency concerned out of appropriations available to such agency.

"(d) The acceptance by the claimant of any such award, compromise, or settlement shall be final and conclusive on the claimant, and shall constituted a complete release of any claim against the United States and against the employee of the Government whose act or omission gave rise to the claim, by reason of the same subject matter."

2. Subsection (b) of section 2401 of Title 28, United States Code, provides, in part, that a claim not exceeding $2,500 must be presented in writing within 2 years after such claim accrues.

3. Section 2678 of Title 28, United States Code, provides, in part, as follows:

"* * * the head of the Federal agency or his designee making an award pursuant to section 2672 of this title * * * may, as a part of such judgment, award, or settlement, determine and allow reasonable attorney fees, which, if the recovery is $500 or more, shall not exceed 10 per centum of the amount recovered under section 2672 of this title * * * to be paid out of but not in addition to the amount of judgment, award, or settlement recovered, to the attorneys representing the claimant."

C. *Procedure for filing claims.* (a) Claims shall be filed on Standard Form 95 "Claim for Damage or Injury," or other written statement of claim. The claim form or statement of claim shall include a demand for money damages in a sum certain for injury to or loss of property, personal injury or death alleged to have occurred by reason of the incident.

(b) Claims shall be filed directly with the local field office of the Bureau or Office of the Department out of whose activities the accident or incident occurred, if known; or if not known with the Associate Solicitor, Territories, Wildlife and Claims, Department of the Interior, Washington, D.C. 20240.

(c) A claim may be presented by the individual or firm sustaining the injury or damages.

(d) Upon receipt of a claim, the time and date of receipt shall be recorded. The claim shall be forwarded with the investigative report immediately to the Regional or Field Solicitor or the Associate Solicitor, Territories, Wildlife and Claims, as appropriate, for determination.

D. *Payment of claims.* (a) When an award is made, the voucher signed by claimant shall be transmitted to the appropriate Bureau or Office of the Department out of whose activities the claim arose.

(b) Prior to payment of any claim which is administratively settled, a signed voucher shall be obtained from the claimant or claimants stating that the award is final and conclusive and constitutes a complete release by the claimant or claimants of any claim against the United States and against the employee of the Government whose act or omission gave rise to the claim.

PART 23—SURFACE EXPLORATION, MINING AND RECLAMATION OF LANDS

Sec.

23.1 Purpose.
23.2 Scope.
23.3 Definitions.
23.4 Application for permission to conduct exploration operations.
23.5 Technical examination of prospective surface exploration and mining operations.
23.6 Basis for denial of a permit, lease, or contract.
23.7 Approval of exploration plan.
23.8 Approval of mining plan.
23.9 Performance bond.
23.10 Reports: Inspection.
23.11 Notice of noncompliance: Revocation.
23.12 Appeals.
23.13 Consultation.

AUTHORITY: The provisions of this Part 23 issued under sec. 32, 41 Stat. 450, as amended, 30 U.S.C. 189; sec. 5, 44 Stat. 1058; 30 U.S.C. 285; sec. 10, 61 Stat. 915; 30 U.S.C. 359; 61 Stat. 681, as amended; 30 U.S.C. 601; and sec. 2, 48 Stat. 1270; 43 U.S.C. 315.

SOURCE: The provisions of this Part 23 appear at 34 F.R. 852, Jan. 18, 1969, unless otherwise noted.

§ 23.1 Purpose.

It is the policy of this Department to encourage the development of the mineral resources under its jurisdiction where mining is authorized. However, the public interest requires that, with respect to the exploration for, and the surface mining of, such minerals, adequate measures be taken to avoid, minimize, or correct damage to the environment—land, water, and air—and to avoid, minimize, or correct hazards to the public health and safety. The regulations in this part prescribe procedures to that end.

§ 23.2 Scope.

(a) Except as provided in paragraphs (b) and (c) of this section, the regulations in this part provide for the protection and conservation of nonmineral resources during operations for the discovery, development, surface mining, and onsite processing of minerals under permits, leases, or contracts issued pursuant to: The Mineral Leasing Act of February 25, 1920, as amended (30 U.S.C. 181–287); the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351–359), the Materials Act of July 31, 1947, as amended (30 U.S.C. 601–604); and title 23, United States Code, section 317, relating to appropriation for highway purposes of lands owned by the United States.

(b) The regulations in this part do not cover the exploration for oil and gas or the issuance of leases, or operations thereunder, for oil and gas under the mineral leasing acts, which are covered by regulations in Subpart 3107 and Part 3120 of this title and 30 CFR Part 221; neither do they cover minerals underlying Indian tribal or allotted lands, which are subject to regulations in Title 25 CFR, nor minerals subject to the general mining laws (30 U.S.C. 21–54); nor minerals under the Materials Act which are under the jurisdiction of the Secretary of Agriculture (74 Stat. 205); nor minerals underlying lands, the surface of which is not owned by the U.S. Government.

NOTE: See Redesignation Table 2 of 43 CFR Part 1000 to find, for appropriate sections of former Subpart 3107 and Part 3120 referred to in the above paragraph (b).

(c) When more than one permit or contract is expected to be issued to dispose of materials in a particular deposit or tract of land, such as community pits or common use areas, no requirement for reclamation will be made in such permits or contracts and the burden of reclamation will be assumed by the Government. In such cases where reclamation is not required in the permit or contract, the permittee or contracting party shall, in addition to payment of the sales price required under his permit or contract, make a reasonable contribution, as determined by the authorized officer, to defray the cost to the Government of reclamation of the land. Such contribution will be deposited in a separate account. In computing such added contribution, the authorized officer shall establish the estimated cost of reclamation upon completion of extractive operations for the deposit and the estimated total volume of material to be extracted. The contribution shall be a proportionate share of the estimated cost of reclamation in the same ratio as the material sold under the permit or contract bears to the total estimated volume of the deposit which is expected to be extracted.

APPENDIX D-2

(d) The regulations in this part shall apply only to permits, leases, or contracts issued subsequent to the date on which the regulations become effective.

[34 F.R. 852, Jan. 18, 1969, as amended at 37 F.R. 12801, June 29, 1972]

§ 23.3 Definitions.

As used in the regulations in this part:

(a) "Mineral leasing acts" means the Mineral Leasing Act of February 25, 1920, as amended and supplemented (30 U.S.C. 181–287) and the Mineral Leasing Act for Acquired Lands (30 U.S.C. 351–359);

(b) "Materials Act" means the Act of July 31, 1947, as amended (30 U.S.C. 601–604);

(c) "Mining Supervisor" means the Area Mining Supervisor, or his authorized representative, of the Geological Survey authorized as provided in 30 CFR 211.3 and 231.2 to supervise operations on the land covered by a permit or lease;

(d) "District manager" means the manager of the district office or other authorized officer of the Bureau of Land Management having administrative jurisdiction of and responsibility for the land covered by a permit, lease, contract, application, or offer;

(e) "Overburden" means all the earth and other materials which lie above a natural deposit of minerals and such earth and other materials after removal from their natural state in the process of mining;

(f) "Area of land to be affected" or "area of land affected" means the area of land from which overburden is to be or has been removed and upon which the overburden or waste is to be or has been deposited, and includes all lands affected by the construction of new roads or the improvement or use of existing roads to gain access to an operation and for haulage;

(g) "Operation" means all of the premises, facilities, roads, and equipment used in the process of determining the location, composition or quality of a mineral deposit, or in developing, extracting, or onsite processing of a mineral deposit in a designated area;

(h) "Method of operation" means the method or manner by which a cut or open pit is made, the overburden is placed or handled, water is controlled or affected and other acts performed by the operator in the process of exploring or uncovering and removing or onsite processing of a mineral deposit;

(i) "Holder" or "operator" means the permittee, lessee, or contractor designated in a permit, lease, or contract;

(j) "Reclamation" means measures undertaken to bring about the necessary reconditioning or restoration of land or water that has been affected by exploration or mineral development, mining or onsite processing operations, and waste disposal, in ways which will prevent or control onsite and offsite damage to the environment.

[34 FR 852, Jan. 18, 1969, as amended at 38 FR 10009, Apr. 23, 1973]

§ 23.4 Application for permission to conduct exploration operations.

No person shall, in any manner or by any means which will cause the surface of lands to be disturbed, explore, test, or prospect for minerals (other than oil and gas) subject to disposition under the mineral leasing acts or the Materials Act without first filing an application for, and obtaining, a permit, lease or contract which authorizes such exploring, testing, or prospecting.

§ 23.5 Technical examination of prospective surface exploration and mining operations.

(a) (1) In connection with an application for a permit or lease under the mineral leasing acts or an application for a permit or an offer to make a contract under the Materials Act, the district manager shall make, or cause to be made, a technical examination of the prospective effects of the proposed exploration or surface mining operations upon the environment. The technical examination shall take into consideration the need for the preservation and protection of other resources, including recreational, scenic, historic, and ecological values; the control of erosion, flooding, and pollution of water; the isolation of toxic materials; the prevention of air pollution; the reclamation by revegetation, replacement of soil, or by other means, of lands affected by the exploration or mining operations; the prevention of slides; the protection of fish and wildlife and their habitat; and the prevention of hazards to public health and safety.

(2) A technical examination of an area should be made with the recognition that actual potential mining sites and mining operations vary widely with respect to topography, climate, surrounding land uses, proximity to densely used areas, and other environmental influences and that mining and reclamation requirements should provide sufficient flexibility to permit adjustment to local conditions.

(b) Based upon the technical examination, the district manager shall formulate the general requirements which the applicant must meet for the protection of nonmineral resources during the conduct of exploration or mining operations and for the reclamation of lands or waters affected by exploration or mining operations. The general requirements shall be made known in writing to the applicant before the issuance of a permit or lease or the making of a contract, and upon acceptance thereof by the applicant, shall be incorporated in the permit, lease, or contract. If an application or offer is made under the Mineral Leasing Act for Acquired Lands and if the lands are under the jurisdiction of an agency other than the Department of the Interior, the requirements must incorporate provisions prescribed by that agency. If the application or offer is made under the Mineral Leasing Act of February 25, 1920, or the Materials Act, and if the lands are under the jurisdiction of an agency other than the Department of the Interior, the district manager shall consult representatives of the agency administering the land and obtain their recommendations for provisions to be incorporated in the general requirements. If the district manager does not concur in the recommendations, the issues shall be referred for resolution to the Under Secretary of the Department of the Interior and the comparable officer of the agency submitting the recommendations. In the case of disagreement on the issues which are so referred, the Secretary of the Interior shall make a determination on the recommendations which shall be final and binding.

(c) In each instance in which an application or offer is made under the mineral leasing acts, the mining supervisor shall participate in the technical examination and in the formulation of the general requirements. If the lands covered by an application or offer are under the jurisdiction of a bureau of the Department of the Interior other than the Bureau of Land Management, the district manager shall consult representatives of the bureau administering the land. If the lands covered by the application or offer are under the jurisdiction of an agency other than the Department of the Interior and that agency makes a technical examination of the type provided for in paragraph (a) of this section, district managers and mining supervisors are authorized to participate in that examination.

(d) Whenever it is determined that any part of the area described in an application or offer for a permit, lease, or contract is such that previous experience under similar conditions has shown that operations cannot feasibly be conducted by any known methods or measures to avoid—

(1) Rock or landslides which would be a hazard to human lives or endanger or destroy private or public property; or

(2) Substantial deposition of sediment and silt into streams, lakes, reservoirs; or

(3) A lowering of water quality below standards established by the appropriate State water pollution control agency, or by the Secretary of the Interior; or

(4) A lowering of the quality of waters whose quality exceeds that required by the established standards—unless and until it has been affirmatively demonstrated to the State water pollution control agency and to the Department of the Interior that such lowering of quality is necessary to economic and social development and will not preclude any assigned uses made of such waters; or

(5) The destruction of key wildlife habitat or important scenic, historical, or other natural or cultural features; the district manager may prohibit or otherwise restrict operations on such part of an area.

(e) If, on the basis of a technical examination, the district manager determines that there is a likelihood that there will be a lowering of water quality as described in paragraphs (d) (3) and (4) of this section caused by the operation, no lease or permit shall be issued or contract made until after consultation with the Federal Water Pollution Control Administration and a finding by the Administration that the proposed operation would not be in violation of the Federal Water Pollution Control Act, as amended (33 U.S.C. sec. 466 et seq.) or of Executive Order No. 11288 (31 F.R. 9261). Where a permit or lease is involved the district manager's determination shall be made in consultation with the mining supervisor.

(f) Each notice of a proposed appropriation of a materials site filed by the Department of Transportation under 23 U.S.C. 317 shall be transmitted to the proper district manager. The district manager shall cause a technical examination to be made as provided in paragraph (a) of this section and shall formulate the requirements which the State highway department or its nominee must meet. If the land covered by the proposed appropriation is under the jurisdiction of a bureau of the Department other than the Bureau of Land Management, the district manager shall consult representatives of the bureau administering the land. If the district manager determines, or, in an instance in which the land is administered by another bureau, a representative of that bureau determines that the proposed appropriation is contrary to the public interest or is inconsistent with the purposes for which such land or materials are reserved, the district manager shall promptly submit the matter to the Secretary of the Interior for his decision. In other instances, the district manager shall notify the Department of Transportation of the requirements and conditions which the State highway department or its nominee must meet.

§ 23.6 Basis for denial of a permit, lease, or contract.

An application or offer for a permit, lease, or contract to conduct exploratory or extractive operations may be denied any applicant or offeror who has forfeited a required bond because of failure to comply with an exploration or mining plan. However, a permit, lease, or contract may not be denied an applicant or offeror because of the forfeiture of a bond if the lands disturbed under his previous permit, lease, or contract have subsequently been reclaimed without cost to the Federal Government.

§ 23.7 Approval of exploration plan.

(a) Before commencing any surface disturbing operations to explore, test, or prospect for minerals covered by the mineral leasing acts the operator shall file with the mining supervisor a plan for the proposed exploration operations. The mining supervisor shall consult with the district manager with respect to the surface protection and reclamation aspects before approving said plan.

(b) Before commencing any surface disturbing operations to explore, test, or prospect for materials covered by the Materials Act the operator shall file with the district manager a plan for the proposed exploration operations.

(c) Depending upon the size and nature of the operation and the requirements established pursuant to § 23.5 the mining supervisor or the district manager may require that the exploration plan submitted by the operator include any or all of the following:

(1) A description of the area within which exploration is to be conducted;

(2) Two copies of a suitable map or aerial photograph showing topographic, cultural and drainage features;

(3) A statement of proposed exploration methods, i.e. drilling, trenching, etc., and the location of primary support roads and facilities;

(4) A description of measures to be taken to prevent or control fire, soil erosion, pollution of surface and ground water, damage to fish and wildlife or other natural resources, and hazards to public health and safety both during and upon abandonment of exploration activities.

(d) The mining supervisor or the district manager shall promptly review the exploration plan submitted to him by the operator and shall indicate to the operator any changes, additions, or amendments necessary to meet the requirements formulated pursuant to § 23.5, the provisions of the regulations in this part, and the terms of the permit.

(e) The operator shall comply with the provisions of an approved exploration plan. The mining supervisor and the district manager may, with respect to such a plan, exercise the authority provided by paragraphs (f) and (g) of § 23.8 respecting a mining plan.

§ 23.8 Approval of mining plan.

(a) (1) Before surface mining operations may commence under any permit or lease issued under the mineral leasing acts the operator must file a mining plan with the mining supervisor and obtain his approval of the plan. Paragraphs (b) through (g) of this section confer authority upon mining supervisors with respect to mining plans pertaining to permits or leases issued under the mineral leasing acts. The mining supervisor shall consult with the district manager with respect to the surface protection and reclamation aspects before approving said plan.

(2) Before surface mining operations may commence under any permit issued or contract made under the Materials Act, the operator must file a mining plan with the district manager and obtain

his approval of the plan. Paragraphs (b) through (g) of this section confer authority upon district managers with respect to mining plans pertaining to permits issued or contracts made under the Materials Act.

(b) Depending on the size and nature of the operation and the requirements established pursuant to § 23.5, the mining supervisor or the district manager may require that the mining plan submitted by the operator include any or all of the following:

(1) A description of the location and area to be affected by the operations;

(2) Two copies of a suitable map, or aerial photograph showing the topography, the area covered by the permit, lease, or contract, the name and location of major topographic and cultural features, and the drainage plan away from the area to be affected;

(3) A statement of proposed methods of operating, including a description of proposed roads or vehicular trails; the size and location of structures and facilities to be built;

(4) An estimate of the quantity of water to be used and pollutants that are expected to enter any receiving waters;

(5) A design for the necessary impoundment, treatment or control of all runoff water and drainage from workings so as to reduce soil erosion and sedimentation and to prevent the pollution of receiving waters;

(6) A description of measures to be taken to prevent or control fire, soil erosion, pollution of surface and ground water, damage to fish and wildlife, and hazards to public health and safety; and

(7) A statement of the proposed manner and time of performance of work to reclaim areas disturbed by the holder's operation.

(c) In those instances in which the permit, lease, or contract requires the revegetation of an area of land to be affected the mining plan shall show:

(1) Proposed methods of preparation and fertilizing the soil prior to replanting;

(2) Types and mixtures of shrubs, trees, or tree seedlings, grasses or legumes to be planted; and

(3) Types and methods of planting, including the amount of grasses or legumes per acre, or the number and spacing of trees, or tree seedlings, or combinations of grasses and trees.

(d) In those instances in which the permit, lease, or contract requires re-grading and backfilling, the mining plan shall show the proposed methods and the timing of grading and backfilling of areas to be affected by the operation.

(e) The mining supervisor or the district manager shall review the mining plan submitted to him by the operator and shall promptly indicate to the operator any changes, additions, or amendments necessary to meet the requirements formulated pursuant to § 23.5, the provisions of the regulations in this part and the terms of the permit, lease, or contract. The operator shall comply with the provisions of an approved mining plan.

(f) A mining plan may be changed by mutual consent of the mining supervisor or the district manager and the operator at any time to adjust to changed conditions or to correct any oversight. To obtain approval of a change or supplemental plan the operator shall submit a written statement of the proposed changes or supplement and the justification for the changes proposed. The mining supervisor or the district manager shall promptly notify the operator that he consents to the proposed changes or supplement or, in the event he does not consent, he shall specify the modifications thereto under which the proposed changes or supplement would be acceptable. After mutual acceptance of a change of a plan the operator shall not depart therefrom without further approval.

(g) If circumstances warrant, or if development of a mining plan for the entire operation is dependent upon unknown factors which cannot or will not be determined except during the progress of the operations, a partial plan may be approved and supplemented from time to time. The operator shall not, however, perform any operation except under an approved plan.

§ 23.9 Performance bond.

(a) (1) Upon approval of an exploration plan or mining plan, the operator shall be required to file a suitable performance bond of not less than $2,000 with satisfactory surety, payable to the Secretary of the Interior, and the bond shall be conditioned upon the faithful compliance with applicable regulations, the terms and conditions of the permit, lease, or contract, and the exploration or mining plan as approved, amended or supplemented. **The bond shall be in** an amount sufficient to satisfy the reclamation requirements of an approved exploration or mining plan, or an approved partial or supplemental plan. In determining the amount of the bond consideration shall be given to the character and nature of the reclamation requirements and the estimated costs of reclamation in the event that the operator forfeits his performance bond.

(2) In lieu of a performance bond an operator may elect to deposit cash or negotiable bonds of the U.S. Government. The cash deposit or the market value of such securities shall be equal at least to the required sum of the bond.

(b) A bond may be a nationwide or statewide bond which the operator has filed with the Department under the provisions of the applicable leasing regulations in Subchapter C of Chapter II of this title, if the terms and conditions thereof are sufficient to comply with the regulations in this part.

(c) The district manager shall set the amount of a bond and take the necessary action for an increase or for a complete or partial release of a bond. He shall take action with respect to bonds for leases or permits only after consultation with the mining supervisor.

(d) Performance bonds will not be required of Federal, State, or other governmental agencies. Where the exploration or mining is actually performed for such Federal, State, or governmental agencies by a contractor who would have to post a bond under the terms of paragraph (a) of this section if he were the operator, such agencies shall require the contractor to furnish a bond payable to the United States which meets the requirements of paragraph (a) of this section. If, for some other purpose, the contractor furnishes a performance bond, an amendment to that bond which meets the requirements of paragraph (a) of this section will be acceptable in lieu of an additional or separate bond.

[34 F.R. 852, Jan. 18, 1969, as amended at 35 F.R. 11237, July 14, 1970]

§ 23.10 Reports: Inspection.

(a) (1) The holder of a permit or lease under the mineral leasing acts shall file the reports required by this section with the mining supervisor. The holder of a permit or a party to a contract under the Materials Act shall file such reports with the district manager.

(2) The provisions of this section confer authority and impose duties upon mining supervisors with respect to permits or leases issued under the mineral leasing acts and upon district managers with respect to permits issued or contracts made under the Materials Act.

(b) Operations report: Within 30 days after the end of each calendar year, or if operations cease before the end of a calendar year, within 30 days after the cessation of operations, the operator shall submit an operations report containing the following information:

(1) An identification of the permit, lease, or contract and the location of the operation;

(2) A description of the operations performed during the period of time for which the report is filed;

(3) An identification of the area of land affected by the operations and a description of the manner in which the land has been affected;

(4) A statement as to the number of acres disturbed by the operations and the number of acres which were reclaimed during the period of time;

(5) A description of the method utilized for reclamation and the results thereof;

(6) A statement and description of reclamation work remaining to be done.

(c) Grading and backfilling report: Upon completion of such grading and backfilling as may be required by an approved exploration or mining plan, the operator shall make a report thereon and request inspection for approval. Whenever it is determined by such inspection that backfilling and grading has been carried out in accordance with the established requirements and approved exploration or mining plan, the district manager shall issue a release of an appropriate amount of the performance bond for the area graded and backfilled. Appropriate amounts of the bond shall be retained to assure that satisfactory planting, if required, is carried out.

(d) Planting report: (1) Whenever planting is required by an approved exploration or mining plan, the operator shall file a report with the mining supervisor or district manager whenever such planting is completed. The report shall—

(i) Identify the permit, lease, or contract;

(ii) Show the type of planting or seeding, including mixtures and amounts;

(iii) Show the date of planting or seeding;

(iv) Identify or describe the areas of the lands which have been planted;

(v) Contain such other information as may be relevant.

(2) The mining supervisor or district manager, as soon as possible after the completion of the first full growing season, shall make an inspection and evaluation of the vegetative cover and planting to determine if a satisfactory growth has been established.

(3) If it is determined that a satisfactory vegetative cover has been established and is likely to continue to grow, any remaining portion of the performance bond may be released if all requirements have been met by the operator.

(e) Report of cessation or abandonment of operations: (1) Not less than 30 days prior to cessation or abandonment of operations, the operator shall report his intention to cease or abandon operations, together with a statement of the exact number of acres of land affected by his operations, the extent of reclamation accomplished and other relevant information.

(2) (i) Upon receipt of such report the mining supervisor or the district manager shall make an inspection to determine whether operations have been carried out and completed in accordance with the approved exploration or mining plan.

(ii) Whenever the lands in a permit, lease or contract issued under the mineral leasing acts or the Materials Act are under the jurisdiction of a bureau of the Department of the Interior other than the Bureau of Land Management the mining supervisor or the district manager, as appropriate, shall obtain the concurrence of the authorized officer of such bureau that the operation has been carried out and completed in accordance with the approved exploration or mining plan with respect to the surface protection and reclamation aspects of such plan before releasing the performance bond.

(iii) Whenever the lands in a permit, lease or contract issued under the Mineral Leasing Act of 1920 or the Materials Act are under the jurisdiction of an agency other than the Department of the Interior, the mining supervisor or the district manager, as appropriate, shall consult representatives of the agency administering the lands and obtain their recommendations as to whether the operation has been carried out and completed in accordance with the approved exploration or mining plan with respect to the surface protection and reclamation aspects of such plan before releasing the performance bond. If the mining supervisor or district manager, as appropriate, do not concur in the recommendations of the agency regarding compliance with the surface protection and reclamation aspects of the approved exploration or mining plan, the issues shall be referred for resolution to the Under Secretary of the Department of the Interior and the comparable officer of the agency submitting the recommendations. In the case of disagreement on issues which are so referred, the Secretary of the Interior shall make a determination which shall be final and binding. In cases in which the recommendations are not concurred in by the mining supervisor or district manager, the performance bond shall not be released until resolution of the issues or until a final determination by the Secretary of the Interior.

(iv) Whenever the lands in a permit or lease issued under the Mineral Leasing Act for Acquired Lands are under the jurisdiction of an agency other than the Department of the Interior, the mining supervisor or the district manager, as appropriate, shall obtain the concurrence of the authorized officer of such agency that the operation has been carried out and completed in accordance with the approved exploration or mining plan with respect to the surface protection and reclamation aspects of such plan before releasing the performance bond.

§ 23.11 Notice of noncompliance: Revocation.

(a) The provisions of this section confer authority and impose duties upon mining supervisors with respect to permits or leases issued under the mineral leasing acts and upon district managers with respect to permits issued or contracts made under the Materials Act. The mining supervisor shall consult with the district manager before taking any action under this section.

(b) The mining supervisor or district manager shall have the right to enter upon the lands under a permit, lease, or contract, at any reasonable time, for the purpose of inspection or investigation to determine whether the terms and conditions of the permit, lease, or contract, and the requirements of the exploration or mining plan have been complied with.

(c) If the mining supervisor or the district manager determines that an operator has failed to comply with the terms and conditions of a permit, lease, or contract, or with the requirements of an exploration or mining plan, or with the provisions of applicable regulations under this part the supervisor or manager shall serve a notice of noncompliance upon the operator by delivery in person to him or his agent or by certified or registered mail addressed to the operator at his last known address.

(d) A notice of noncompliance shall specify in what respects the operator has failed to comply with the terms and conditions of a permit, lease, or contract, or the requirements of an exploration or mining plan, or the provisions of applicable regulations, and shall specify the action which must be taken to correct the noncompliance and the time limits within which such action must be taken.

(e) Failure of the operator to take action in accordance with the notice of noncompliance shall be grounds for suspension by the mining supervisor or the district manager of operations or for the initiation of action for the cancellation of the permit, lease, or contract and for forfeiture of the performance bond required under § 23.9.

[34 FR 852, Jan. 18, 1969, as amended at 39 FR 27139, July 25, 1974]

§ 23.12 Appeals.

(a) A person adversely affected by a decision or order of a district manager or of a mining supervisor made pursuant to the provisions of this part shall have a right of appeal to the Board of Land Appeals, Office of Hearings and Appeals, whenever the decision appealed from was rendered by a district manager, or to the Director of the Geological Survey if the decision or order appealed from was rendered by a mining supervisor, and the further right to appeal to the Board of Land Appeals from an adverse decision of the Director of the Geological Survey unless such decision was approved by the Secretary prior to promulgation.

(b) Appeals to the Board of Land Appeals shall be made pursuant to part 4 of this title. Appeals to the Director of the Geological Survey shall be made in the manner provided in 30 CFR part 290.

(c) In any case involving a permit, lease, or contract for lands under the jurisdiction of an agency other than the Department of the Interior, or a bureau of the Department of the Interior other than the Bureau of Land Management, the officer rendering a decision or order shall designate the authorized officer of such agency as an adverse party on whom a copy of any notice of appeal and any statement of reasons, written arguments, or briefs must be served.

(d) Hearings to present evidence on an issue of fact before an administrative law judge may be ordered by the Board of Land Appeals or the Director of the Geological Survey, as the case may be, in accordance with the procedure set forth in Part 4 of this title.

[35 F.R. 10009, June 18, 1970, as amended at 36 FR 7206, Apr. 15, 1971; 38 FR 10000, Apr. 23 1973]

§ 23.13 Consultation.

Whenever the lands included in a permit, lease, or contract are under the jurisdiction of an agency other than the Department of the Interior or under the jurisdiction of a bureau of the Department of the Interior other than the Bureau of Land Management, the mining supervisor or the district manager, as appropriate, shall consult the authorized officer of such agency before taking any final action under §§ 23.7, 23.8, 23.10 (c) and (d) (2) and (3), and 23.11(c).

PART 24—PRESERVATION, USE, AND MANAGEMENT OF FISH AND WILDLIFE RESOURCES

Sec.
24.1 Policy.
24.2 Cooperation with States.
24.3 Procedures.
24.4 Exemptions.
24.5 Hunting, fishing, trapping in National Park System.
24.6 Cooperative agreements.

AUTHORITY: The provisions of this Part 24 issued under 43 U.S.C. 1201.

SOURCE: The provisions of this Part 24 appear at 36 F.R. 21034, Nov. 3, 1971, unless otherwise noted.

§ 21.1 Policy.

The Secretary of the Interior recognizes that fish and wildlife resources must be maintained for their aesthetic, scientific, recreation, and economic importance to the people of the United States, and that because fish and wildlife populations are totally dependent upon their habitat, the several States and the Federal Government must work in harmony for the common objective of developing and utilizing these resources. It is

the policy of the Secretary of the Interior further to strengthen and support, to the maximum extent possible, the missions of the States and the Department of the Interior in the attainment of this objective.

§ 21.2 Cooperation with States.

The effective husbandry of such resources requires the cooperation of State and Federal Government because:

(a) The several States have the authority to control and regulate the capturing, taking, and possession of fish and resident wildlife by the public within State boundaries;

(b) The Congress, through the Secretary of the Interior, has authorized and directed to various Interior agencies certain responsibilities for the conservation and development of fish and wildlife resources and their habitat.

§ 21.3 Procedures.

The following procedures will apply to all areas administered by the Secretary of the Interior through the National Park Service, Bureau of Sport Fisheries and Wildlife, Bureau of Land Management, and Bureau of Reclamation (thereinafter referred to as the Federal agencies). These Federal agencies will:

(a) Within their statutory authority, institute fish and wildlife habitat management practices in cooperation with the States which will assist the States in accomplishing their respective, comprehensive, statewide resource plans;

(b) Permit public hunting, fishing, and trapping within statutory limitations and in a manner compatible with the primary objectives for which the lands are administered. Such hunting, fishing, and trapping and the possession and disposition of fish, game, and fur animals shall be conducted in all other respects within the framework of applicable State laws, including requirements for the possession of appropriate State licenses or permits. The Federal agencies may, after consultation with the States, close all or any portion of land under their jurisdiction to public hunting, fishing, or trapping in order to protect the public safety or to prevent damage to Federal lands or resources thereon, and may impose such other restrictions as are necessary to comply with management objectives;

(c) Consult with the States and comply with State permit requirements in connection with the activities listed below, except in instances where the Secretary of the Interior determines that such compliance would prevent him from carrying out his statutory responsibilities:

(1) In carrying out research programs involving the capturing, taking, or possession of fish and wildlife or programs involving introduction of fish and wildlife;

(2) For the planned and orderly removal of surplus or harmful populations of fish and wildlife except where emergency situations requiring immediate action make such consultation and compliance with State permit requirements infeasible;

(3) In the disposition of fish and wildlife taken under subparagraph (1) or (2) of this paragraph.

§ 21.4 Exemptions.

Exempted from this regulation are the following:

(a) The control and regulation by the United States, in the area in which an International convention or treaty applies, of the taking of those species and families of fish and wildlife expressly named or otherwise covered under any international treaty or convention to which the United States is a party;

(b) Any species of fish and wildlife control over which has been ceded or granted to the United States by any State;

(c) Areas over which the States have ceded exclusive jurisdiction to the United States.

§ 21.5 Hunting, fishing, trapping in National Park System.

Nothing contained herein shall be construed as permitting public hunting, fishing, or trapping on National Parks, Monuments, or Historic areas of the National Parks System, except where Congress or the Secretary of the Interior has otherwise declared that hunting, fishing, or trapping is permissible.

§ 21.6 Cooperative agreements.

The Federal agencies and States will enter into written cooperative agreements containing the plans, terms, and conditions of each party in carrying out the intent of this regulation when such agreements are desired by the States. Such agreements will be reviewed periodically by both parties and, when appropriate, adjusted to reflect changed conditions.

SPECIAL

Department of the Interior
OLOGICAL SURVEY
UNRISE VALLEY DRIVE
TON, VIRGINIA 22092

POTASH

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U.S. GEOLOGICAL SURVEY
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Memorandum

To: Secretary of the Interior
Through Acting Deputy Assistant Secretary - Energy & Minerals

W A Vogely
FEB 20 1974

From: Director, Geological Survey

Subject: Drilling of oil and gas tests in the Secretary's Potash Area, New Mexico

As you will recall, several recent controversies as to whether to permit the drilling of certain oil and gas tests in the Secretary's Potash Area precipitated a review of Departmental policy with respect to operations in this multiple use area.

The Conservation Division has now completed its study of the situation. Items such as (1) the stated position of the potash and oil and gas industries; (2) past approval actions; (3) the need to maintain a harmonious relationship with the State of New Mexico; (4) the Nation's requirements for additional energy sources; and, (5) the conservation of our most important domestic potash supply have been considered. Based on this study, the Chief, Conservation Division believes that action is required if we are to avoid similar conflicts in the future, and the Division has made certain recommendations as set forth in the enclosed memorandum.

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ICA-2P
Roswell
(I. Ralph Trujillo, Chmn, N.M.OCC
A.L. Pete Porter, St. Geol.-Sec-Dir N.M.OCC
NOF + Carl T. + Don VS. + Bob Fulton + Jim G. (PM + Jim K.)

Copies sent Porter etc. by wyatt

CC: FREDERICK ✓
TRAYWICK
VAN SICKLE
GILLHAM
BROWN
KNAUF
FILE

If you concur in these recommendations, please indicate in the space provided, and the Conservation Division will prepare the necessary implementation papers.

W. A. Radlinski

Acting Director

Determination is hereby made that adoption of the recommendations contained in Chief, Conservation Division's memorandum of February 14, 1974, would be in the public interest and authority to proceed as recommended is hereby granted.

Date MAR 1 1974

John C Whitaker

Acting Secretary of the Interior

Enclosure

Appendix D-3

United States Department of the Interior
GEOLOGICAL SURVEY
12201 SUNRISE VALLEY DRIVE
RESTON, VIRGINIA 22092

FEB 14 1974

MAR 11 1974
U. S. GEOLOGICAL SURVEY
ROSWELL, NEW MEXICO

Memorandum

To: Acting Director, Geological Survey FEB 15 1974

From: Chief, Conservation Division

Subject: Drilling of oil and gas tests in the Secretary's Potash Area, southeastern New Mexico

By order of October 16, 1951, the Secretary of the Interior delineated an area embracing 298,345 acres in southeastern New Mexico as a designated potash area. This order revoked the Secretary's Order of February 6, 1939, thereby eliminating the ban on oil and gas leasing which had been in effect on 42,235 acres of these same lands. Since that time, there have been periodic differences of opinion between the potash mining companies and the oil industry as to whether a particular oil and gas well should be drilled in the Area. Secretarial Order of May 11, 1965, expanded the Secretary's Potash Area to include 420,212 acres and eased some of the restrictions previously imposed on oil and gas drilling in the Area. The discovery and development of extensive and very valuable langbeinite potash deposits, and the currently escalating price of oil and gas which has given impetus to exploratory activity in the Area by the oil and gas industry have resulted in a situation where conflicts of interest between the two industries are inevitable. In each of the several recent controversies, neither side has seemed willing to compromise, and each new confrontation appears to magnify the differences of opinion.

As to Federal lands in the Secretary's Potash Area, the Area Oil and Gas Supervisor, in consultation with the Area Mining Supervisor, is charged with the responsibility of deciding which proposed oil and gas tests may be drilled. These have never been easy decisions, but with today's energy shortage and the need to protect our most important source of domestic potash, these decisions have become more difficult.

Accordingly, a complete policy review was initiated in April of 1973. As a part of this study, Assistant Secretary Wakefield and other Departmental representatives met with delegations from the New Mexico Oil and Gas Association and the seven potash operating companies in

Washington, D.C., on May 8 and August 7, 1973, respectively. The Area Oil and Gas Supervisor and the Area Mining Supervisor reviewed the position documents presented by both industries and submitted a joint report dated August 24, a copy of which is enclosed. The Conservation Manager, Central Region, supplied his comments and recommendations in a memorandum of September 6, a copy of which is also enclosed.

The results of this study indicated that action should be taken to assure that the decisions of our Supervisors reflect Departmental policy, are made as fairly as possible, result in proper conservation of both of these important mineral resources, and do not unduly impede the development of either resource. It was concluded (1) that certain facets of Departmental policy affecting operations in the Secretary's Potash Area should be reaffirmed; (2) that more clear-cut procedures to assist the two Supervisors in their decision-making processes should be adopted; and (3) that guidelines to implement the new procedures should be developed. Based on these conclusions, certain proposed recommendations were submitted for your consideration by our memorandum of December 7, 1973, and, upon your concurrence, those recommendations were forwarded by memorandum of December 10 to the Office of the Assistant Secretary - Energy and Minerals for further consideration. Subsequently, copies of the December 7 memorandum were furnished to representatives of the New Mexico oil and gas and potash industries for their review. On January 31, Deputy Assistant Secretary Rigg and other Departmental personnel conducted a meeting in Albuquerque, New Mexico, to discuss the proposed new procedures. Approximately 50 people attended the meeting, of which 35 were representatives of the two industries. A copy of the attendance list is enclosed. The discussions at that meeting were very productive. They not only disclosed the need for revision of some segments of the proposed procedures but also seemed to promote a spirit of cooperation between the two industries. As a result of this further review, we now recommend that:

Part 1. The Department reaffirm its position that the Secretarial Order of May, 1965, adequately protects the rights of the oil and gas and potash industries. However, the Area Mining Supervisor is to initiate action to bring about the expansion of Secretary's Potash Area to include those known potash deposits in T. 22 S., R. 31 E., T. 23 S., Rs. 29 and 31 E., and T. 24 S., Rs. 30 and 31 E., N.M.P.M., presently outside the designated Area.

Part 2. Each potash lessee will be required by April 15, 1974, to file with the Mining Supervisor a map or maps on which has been delineated the following information with respect to the Federal potash leases which it then holds:

a. The areas where active mining operations are now in progress on one or more ore zones.

b. The areas where mining operations have been completed on one or more ore zones.

c. The presently unmined areas which are considered to contain a minable reserve in one or more ore zones, i.e., those areas (enclaves) where potash ore is known to exist in sufficient thickness and quality to be minable under present day technology and economics.

d. The areas within these enclaves which are believed to be barren of commercial ore.

These maps are to be updated effective January 1, 1975, and thereafter on an annual basis. The Area Geologist, in consultation with the Mining Supervisor, will prepare the data required in subparts c. and d. above for unleased Federal lands in the Secretary's Potash Area.

The potash lessee will be responsible for submitting sufficient data to justify any area which is proposed as a minable reserve. The Area Geologist, in consultation with the Mining Supervisor, will review the information furnished in this regard and make any revision in the boundary of a proposed minable reserve (potash enclave) which is considered to be consistent with the data available at the time of each such analysis. All maps which are developed pursuant to this Part will be updated between the required revision dates whenever new information becomes available.

The Area Geologist and the Area Mining Supervisor will complete the analysis of the initial data supplied by the potash lessees and commit their total findings to a map or maps of suitable scale by June 1, 1974. These maps will be revised as necessary to reflect the latest available information. Copies of such map(s) will be available to all interested parties through map reproduction companies located in Roswell, New Mexico.

Part 3. After April 15, 1974, it will be Departmental policy to deny approval of most applications for permits to drill oil and gas tests from surface locations within the potash enclaves established in accordance with Part 2 hereof. Two exceptions to this policy will be permitted under the following conditions:

a. Drilling of vertical or directional holes will be allowed to take place from barren areas within the potash enclaves when the Mining Supervisor determines that such operations will not adversely affect active or planned mining operations in the immediate vicinity of the proposed drillsite.

b. Drilling of vertical or directional holes will be permitted to take place from a drilling island located within a potash enclave when: (1) there are no barren areas within the enclave or drilling is not permitted on the established barren area(s) within the enclave because of interference with mining operations; and, (2) the objective oil and gas formation beneath the lease cannot be reached by a well which is vertically or directionally drilled from any permitted location within the barren area(s); or, (3) in the opinion of the Oil and Gas Supervisor, the target formation beneath a remote interior lease cannot be reached by a well directionally drilled from a surface location outside the potash enclave. Under these circumstances, the Mining Supervisor will, in consultation with the Oil and Gas Supervisor, establish an island within the potash enclave from which the drilling of that well and subsequent wells will be permitted. The Mining Supervisor in establishing any such island will, consistent with the data supplied by the Oil and Gas Supervisor regarding present directional drilling capabilities, select a site which will minimize the loss of potash ore. No island will be established within one mile of any area where approved mining operations will be conducted within three years. To assist the Mining Supervisor in this regard, he may require potash mining operators to furnish a three-year mining plan.

Part 4. In order to protect the equities between oil and gas lessees while at the same time reducing the number of oil and gas wells which operators propose to drill in the Potash Area, the Oil and Gas Supervisor will make greater use of his prerogative to require unitization. Unitization will be mandatory in those cases where completion of the proposed well as a producer would result in the drainage of oil and gas from beneath other Federal lands within a potash enclave. In other words, unitization will be a prerequisite to the approval of any well which is (1) located adjacent to an enclave (within a quarter of a mile if an oil test or one-half mile if a gas test) and which is to be drilled vertically to the prospective formation; (2) to be directionally drilled from an adjacent surface location to bottom in a formation beneath an enclave; or (3) to be vertically or directionally drilled from a barren area or island within an enclave.

Part 5. The Department reaffirm its intent to cooperate with the New Mexico Oil Conservation Commission (NMOCC) in the implementation of that agency's rules and regulations. In that regard, the potash lessees shall continue to have the right to protest to the NMOCC the drilling of a proposed oil and gas test on Federal lands provided that the location of said well is within the State of New Mexico's "Oil-Potash Area" as that Area is delineated by NMOCC Order No. 111, as amended.

Part 6. The Department reassert its prerogative to make the final decision of whether to approve the drilling of any proposed well on Federal oil and gas leases within the Secretary's Potash Area.

Part 7. Applications for permits to drill vertical tests for oil and gas at locations that are in the Secretary's Potash Area but outside the State of New Mexico's Oil-Potash Area and which do not directly offset an enclave (within a quarter mile if an oil test or within one-half mile if a gas test) will be routinely approved by the Oil and Gas Supervisor after review by the Mining Supervisor.

Part 8. Future controversies as to whether to permit the drilling of an oil and gas test in the Secretary's Potash Area which cannot be resolved in the field are to be referred to the Chief, Conservation Division, with a recommendation from the Regional Conservation Manager.

If these recommendations meet with your approval, we suggest that this memorandum be sent to the Assistant Secretary - Energy & Minerals for review and the subsequent authorization of the Secretary of the Interior to proceed as recommended.

Russell G. Wayland
Chief, Conservation Division

Enclosures

CC: CD File
Reg. Cons. Mgr., Denver
Area Mining Supv., Carlsbad
Area O&G Supv., Roswell
Area Geologist, Roswell
OS&D Section
Desk Files (CCD) (ADE-O) (AVB) (ERW) (WCS) (TOF)

RWayland:JDuletsky:ABailey:EWyatt:WSheldon:TFriz:dw:2/14/74

BEFORE THE OIL CONSERVATION COMMISSION
OF THE STATE OF NEW MEXICO

IN THE MATTER OF DEFINING BOUNDARIES
OF POTENTIAL OIL PRODUCING AREAS IN
EDDY AND LEA COUNTIES, NEW MEXICO,
WITHIN WHICH POTASH MINERALS ARE BEING
PRODUCED OR POTENTIAL POTASH PRODUCING
LANDS ARE LOCATED,

CASE NO. 278
ORDER NO. R-111

ORDER OF THE COMMISSION

BY THE COMMISSION:

This cause came on for hearing before the Oil Conservation Commission of New Mexico, hereinafter referred to as the "Commission", on June 21, 1951, and for further hearing on July 10, 1951, and the Commission, a quorum being present, having considered the testimony adduced and the exhibits introduced in evidence and arguments presented and being fully advised in the premises,

FINDS:

(1) That due notice having been given, according to law, and all interested parties having appeared, the Commission has jurisdiction of this cause, and the subject matter thereof.

(2) That an area defining potential oil and gas reserves within which are proved and potential potash deposits, and the promulgation of rules and regulations for the orderly development of oil and gas resources in such an area known to be productive of potash is within the authority of the Commission for the protection of correlative rights, the promotion of conservation, and the prevention of waste.

IT IS THEREFORE ORDERED:

That this order shall be known as THE RULES AND REGULATIONS GOVERNING THE EXPLORATION AND PRODUCTION OF OIL AND GAS IN CERTAIN AREAS AND SUB-AREAS HEREIN DEFINED AND KNOWN TO CONTAIN PROVED AND SEMI-PROVED POTASH MINERALS IN THE AREA AND SUB-AREAS HEREINAFTER SET OUT.

I
OBJECTIVE

The objective of these Rules and Regulations is to prevent waste, protect correlative rights, assure maximum conservation of Oil and Gas resources of New Mexico and permit the simultaneous economic recovery of potash minerals in the area hereinafter defined.

II
THE POTASH-OIL AREAS

(1) These Rules and Regulations are applicable to oil and gas operations and to exploration for and production of oil and gas in proven or potential Potash-Oil areas herein as "Area A" and "Area B".

(a) The potash-oil area represents the area in various parts of which potash mining operations are now in progress, or in which core tests indicate potential potash reserves are located and is described, as follows:

T. 19S, R. 29E
Sec. 11 - SE/4
Sec. 12 - S/2
Sec. 13 and 14 - all
Sec. 23 - N/2
Sec. 24 - N/2

T. 20S, R. 29E
Sec. 12 - NE/4 SE/4 and S/2 SE/4
Sec. 13 - NE/4 and S/2
Sec. 22 to 27, inclusive
Sec. 34 to 36, inclusive

T. 21 S, R. 29E
Sec. 1 and 2, all
Sec. 3 - E/2
Sec. 10 - E/2
Sec. 11 to 14, inclusive
Sec. 15 - E/2
Sec. 23 - N/2
Sec. 24 and 25 - all
Sec. 35 - E/2
Sec. 36 - all

T. 22S, R. 29E
Sec. 1 and 2 - all
Sec. 3 - S/2
Sec. 9 - E/2
Sec. 10 to 16, inclusive
Sec. 17 - E/2
Sec. 20 - E/2
Sec. 21 to 28, inclusive
Sec. 33 to 36, inclusive

T. 23S, R. 29E
Sec. 1 to 3, inclusive
Sec. 4 - E/2
Sec. 9 - E/2
Sec. 10 to 15, inclusive
Sec. 22 to 27, inclusive
Sec. 34 to 36, inclusive

T. 18S, R. 30E
Sec. 12-S/2
Sec. 13 and 14 - all
Sec. 15 - SE/4
Sec. 21 - SE/4
Sec. 22 to 24, inclusive
Sec. 25 - W/2
Sec. 26 to 28, inclusive
Sec. 29 - SE/4

T. 18S. R. 30E
Sec. 32 - SW/4 and E/2
Sec. 33 and 34 - all
Sec. 35 - W/2

T. 19S. R. 30E
Sec. 2 to 5, inclusive
Sec. 6 - SE/4
Sec. 7 - NE/4 and S/2
Sec. 8 to 30, inclusive
Sec. 32 to 36, inclusive

T. 20S. R 30E
Sec. 1 to 36, inclusive

T. 21S. R. 30E
Sec. 1 to 11, inclusive
Sec. 12 - S/2
Sec. 13 to 22, inclusive
Sec. 23, - N/2
Sec. 24 - N/2
Sec. 27 to 34, inclusive
Sec. 35 - S/2

T. 22S. R. 30E
Sec. 1 to 24, inclusive
Sec. 25 - W/2
Sec. 26 to 35, inclusive
Sec. 36 - W/2

T. 23S. R. 30E
Sec. 1 - S/2
Sec. 2 to 36, inclusive

T. 24S. R. 30E
Sec. 1 - N/2
Sec. 2 - N/2
Sec. 3 - N/2

T. 18S. R. 31E
Sec. 18 - W/2

T. 19S. R. 31E
Sec. 9 and 10 - all
Sec. 11 - W/2
Sec. 14 - W/2
Sec. 15 to 17, inclusive
Sec. 19 to 22, inclusive
Sec. 23 - W/2
Sec. 25 - S/2
Sec. 26 to 36, inclusive

T. 20S. R. 31E
Sec. 1 to 36, inclusive

T. 21S, R. 31E
Sec. 1 - N/2
Sec. 2 - N/2
Sec. 4 - W/2
Sec. 5 and 6 - all
Sec. 18 - S/2
Sec. 19 - N/2

T. 22S, R. 31E
Sec. 4 to 9, inclusive
Sec. 17 and 18 - all
Sec. 19 - N/2

T. 23S, R. 31E
Sec. 7 - all
Sec. 8 - S/2
Sec. 16 - SW/4
Sec. 17 to 20, inclusive
Sec. 21 - W/2
Sec. 28 to 33, inclusive

T. 24S, R. 31E
Sec. 4 to 6, inclusive

T. 19S, R. 32E
Sec. 23, S/2
Sec. 24 to 27, inclusive
Sec. 28 - S/2
Sec. 31 - S/2
Sec. 32 - S/2
Sec. 33 to 36, inclusive

T. 20S, R. 32E
Sec. 1 to 36, inclusive

T. 21S, R. 32E
Sec. 1 to 17, inclusive
Sec. 21 to 27, inclusive
Sec. 35 and 36 - all

T. 19S, R. 33E
Sec. 19 - all
Sec. 30 and 31 - all

T. 20S, R. 33E
Sec. 5 to 9, inclusive
Sec. 15 to 23, inclusive
Sec. 25 to 36, inclusive

T. 21S, R. 33E
Sec. 4 to 9, inclusive
Sec. 16 to 21, inclusive
Sec. 28 to 33, inclusive

T. 22S, R. 33E
Sec. 4 to 6, inclusive

T. 20S, R. 34E
Sec. 31 - all

(b) Area "A" represents the area in various parts of which potash mining operations are now in progress and is described, as follows:

T. 19S, R. 30E
Sec. 9 - SE/4 NW/4, E/2 SW/4, S/2 NE/4, SE/4
Sec. 10 - SW/4 NW/4, W/2 SW/4
Sec. 15 - NW/4 NW/4
Sec. 16 - N/2 NE/4, NE/4 NW/4
Sec. 26 - S/2 NW/4, SW/4 NE/4, W/2 SE/4, SW/4
Sec. 27 - S/2 NE/4,SE/4 NW/4, NE/4 SW/4, S/2 SW/4, SE/4
Sec. 28 - SE/4 SE/4
Sec. 33 - SE/4 NW/4, NE/4 NE/4, S/2 NE/4, E/2 SW/4, SE/4
Sec. 34 - all
Sec. 35 - NW/4, W/2 NE/4, NW/4 SE/4, N/2 SW/4, SW/4 SW/4

T, 20S, R-30E
Sec. 2 - W/2 NW/4, NW/4 SW/4
Sec. 3 - N/2, SW/4, N/2 SE/4, SW/4 SE/4
Sec. 4 - E/2, SW/4, E/2 NW/4, SW/4 NW/4
Sec. 5 - SE/4 NE/4, E/2 SE/4, SW/4 SE/4, SE/4 SW/4
Sec. 7 - SE/4 SE/4
Sec. 8 - E/2, E/2 NW/4, E/2 SW/4, SW/4 SW/4
Sec. 9 - N/2, SW/4, N/2 SE/4,SW/4, SE/4
Sec. 10 - NW/4, W/2 NE/4, NW/4, NW/4 SE/4, N/2 SW/4
Sec. 16 - N/2 NW/4, NW/4 NE/4
Sec. 17 - W/2, N/2 NE/4, SW/4 NE/4, W/2 SE/4
Sec. 18 - E/2 NE/4, E/2 SE/4
Sec. 19 - NE/4 NE/4
Sec. 20 - N/2 NW/4, NW/4 NE/4
Sec. 25 - SW/4 SW/4
Sec. 26 - SE/4 SW/4, S/2 SE/4
Sec. 35 - E/2 NW/4, NE/4, N/2 SE/4, NE/4 SW/4
Sec. 36 - W/2 NW/4, NW/4 SW/4

T. 21S, R. 29E
Sec. 1 - SE/4, S/2 NE/4, SE/4 NW/4, NE/4 SW/4, S/2 SW/4
Sec. 2 - SE/4 SE/4
Sec. 11 - NE/4 NE/4, S/2 NE/4, SE/4 NW/4, E/2 SW/4, SE/4
Sec. 12 - all
Sec. 13 - N/2, SE/4, N/2 SW/4, SE/4 SW/4
Sec. 14 - E/2 NW/4, NE/4, NE/4 SW/4, N/2 SE/4
Sec. 24 - NE/4 NW/4, N/2 NE/4
Sec. 25 - SE/4 SW/4, S/2 SE/4
Sec. 36 - E/2 NW/4, E/2 SW/4, E/2

T. 22S. R. 29E
Sec. 1 - E/2 NW/4, SW/4 NW/4, SW/4, E/2
Sec. 2 - SE/4 NE/4, E/2 SE/4
Sec. 11 - E/2 NE/4, NE/4 SE/4
Sec. 12 N/2, N/2 SW/4, N/2 SE/4

T. 21S. R. 30E
Sec. 6 - SW/4 NW/4, W/2 SW/4
Sec. 7 - NW/4 NW/4, S/2 NW/4, SW/4 NE/4, SW/4, W/2 SE/4
Sec. 18 - NW/4, W/2 NE/4, N/2 SW/4, SW/4 SW/4, NW/4 SE/4
Sec. 19 - NW/4 NW/4

T. 21S. R. 30E
Sec. 29 - SW/4 SW/4
Sec. 30 - S/2 SW/4, S/2 SE/4
Sec. 31 - all
Sec. 32 - W/2 NW/4, W/2 SW/4

T. 22S. R. 30E
Sec. 5 - W/2 NW/4, NW/4 SW/4
Sec. 6 - N/2, SW/4, N/2 SE/4, SW/4 SE/4
Sec. 7 - N/2 NW/4, SW/4 NW/4, NW/4 NE/4, NW/4 SW/4

(c) Area "B" is defined as that area in which core tests indicate potential potash reserves and includes the entire potash-oil area as described under "The Potash-Oil Areas" Sec. (1) (a), of this order, except and excluding lands defined and described as area "A" in "The Potash-Oil Areas, "Sec. (1) (b) of this order.

(2) Area "A" and "B" as hereinabove defined may be contracted or expanded by the Commission from time to time as circumstances or conditions may warrant, after due notice and hearing.

III

EXPLORATION OF AREAS

(1) Area "A"

(a) Drilling of oil and gas exploratory test wells shall not be permitted in Area "A" except upon leases outstanding as of the effective date of these regulations, provided, that oil and gas exploratory test wells shall not be drilled through any open potash mines or within 1,320 feet thereof unless agreed to in writing by the potash lessee involved.

(b) Any oil or gas leases hereafter issued for lands within Area "A" shall be subject to these regulations.

(c) All future drilling of oil and gas exploratory test wells in Area "A" shall be further subject to these rules and regulations.

(d) Where oil and gas wells are in production in Area "A", no potash mine opening shall be driven to within less than 100 feet of such wells so that protection of both wells and mine can be afforded.

(e) Proposals to unitize with respect to land within Area "A", as herein defined and described, will be considered on their merits.

(2) Area "B"

(a) Oil and gas exploratory test wells may be drilled in Area "B" in accordance with these rules and regulations.

(3) Upon the discovery hereafter of oil and gas in Areas "A" or "B", the Oil Conservation Commission shall promulgate field or pool rules for the affected area after due notice and hearing.

(4) Nothing herein shall be construed to prevent unitization agreements involving lands in Areas "A" or "B", or both.

IV
DRILLING AND CASING PROGRAM

(1) For the purpose of the regulations and the drilling of oil and gas exploratory test wells, shallow and deep zones are defined, as follows:

(a) The shallow zone shall include all formations above the base of the Delaware sand or above a depth of 5,000 feet, whichever is the lesser.

(b) The deep zone shall include all formations below the base of the Delaware sand or below a depth of 5,000 feet, whichever is the lesser.

(2) Surface Casing String:

(a) A Surface casing string of new, second-hand, or reconditioned pipe shall be set in the "Red Bed" section of the Basal Rustler formation immediately above the salt section, or in the anhydrite at the top of the salt section, as determined necessary by the regulatory representative approving the drilling operations and shall be cemented with not less than one hundred and fifty percent (150) percent of calculated volume necessary to circulate cement to the ground surface.

(b) Cement shall be allowed to stand a minimum of twelve (12) hours under pressure and a total of twenty-four (24) hours before drilling the plug or initiating tests.

(c) Casing and water-shut-off tests shall be made both before and after drilling the plug and below the casing seat as follows:

(i) If rotary tools are used, the mud shall be displaced with water and a hydraulic pressure of six hundred (600) pounds per square inch shall be applied. If a drop of one hundred (100) pounds per square inch or more should occur within thirty (30) minutes, corrective measures shall be applied.

(ii) If cable tools are used, the mud shall be bailed from the hole, and if the hole does not remain dry for a period of one hour, corrective measures shall be applied.

(d) The above requirements for the surface casing string shall be applicable to both the shallow and deep zones.

(3) Salt Protection String:

(a) A salt protection string of new, second-hand, or reconditioned pipe shall be set not less than one hundred (100) feet nor more than two hundred (200) feet below the base of the salt section.

(b) The salt protection string shall be cemented, as follows:

(i) For wells drilled to the shallow zone, the string may be cemented with a nominal volume of cement for testing purposes only. If the exploratory test well is completed as a productive well, the string shall be recemented with sufficient cement to fill the annular space back of the pipe from the top of the first cementing to the surface or to the bottom of the cellar, or may be cut and pulled if the production string is cemented to the surface as provided in sub-section IV (5), (a), (i) below.

(ii) For wells drilled to the deep zone, the string must be cemented with sufficient cement to fill the annular space back of the pipe from the casing seat to the surface or to the bottom of the cellar.

(c) If the cement fails to reach the surface or the bottom of the cellar, where required, the top of the cement shall be located by a temperature or gamma ray survey and additional cementing shall be done until the cement is brought to the point require

(d) The fluid used to mix with the cement shall be saturated with the salts common to the zones penetrated and with three (3 percent) percent of calcium chloride by weight of cement.

(e) Centralizers shall be spaced on at least every one hundred fifty (150) feet of the salt protection string below the surface casing string.

(f) Cement shall be allowed to stand a minumum of twelve (12) hours under pressure and a total of twenty-four hours (24) before drilling the plug or initiating tests.

(g) Casing tests shall be made both before and after drilling the plug and below the casing seat, as follows:

(i) If rotary tools are used, the mud shall be displaced with water and a hydraulic pressure of one thousand (1000) pounds per square inch shall be applied. If a drop of one hundred (100) pounds per square inch or more should occur within thirty (30) minutes, corrective measures shall be applied.

(ii) If cable tools are used, the mud shall be bailed from the hole and if the hole does not remain dry for a period of one hour, corrective measures shall be applied.

(h) The above requirements for the salt protection string shall be applicable to both the shallow and deep zones except for sub-section IV (3), (b), (i) and (ii) above.

(4) Intermediate String:

(a) In the drilling of oil and gas exploratory test wells to the deep zone, an intermediate string shall be set at sufficient depth to case-off all formations in the shallow zone and shall be cemented with sufficient cement to fill the annular space back of the pipe from the casing seat to the surface or to the bottom of the cellar.

(b) Cementing procedures and casing tests for the intermediate string shall be the same as provided under sub-sections IV (3), (c), (f) and (g) for the salt protection string.

(5) Production String:

(a) A production string shall be set on top or through the oil or gas pay zone and shall be cemented as follows:

(i) For wells drilled to the shallow zone the production string shall be cemented to the surface if the salt protection string was cemented only with a nominal volume for testing purposes, in which case the salt protection string can be cut and pulled before the production string is cemented; provided, that if the salt protection string was cemented to the surface, the production string shall be cemented with a volume adequate to protect the pay zone and the casing above such zone.

(ii) For wells drilled to the deep zone, the production string shall be cemented with a volume adequate to protect the pay zone and the casing above such zone; provided, that is, no intermediate string shall have been run and cemented to the surface, the production string shall be cemented to the surface.

(b) Cementing procedures and casing tests for the production string shall be the same as provided under sub-sections IV (3) (c), (f) and (g) for the salt protection string.

V

DRILLING FLUID FOR SALT SECTION

The fluid used while drilling the salt section shall consist of water, to which has been added sufficient salts of a character common to the zone penetrated to completely saturate the mixture. Other admixtures may be added to the fluid by the operator in overcoming any specific problem. This requirement is specifically intended to prevent enlarged drill holes.

VI

PLUGGING AND ABANDONMENT OF WELLS

All wells heretofor and hereafter drilled within Areas "A" and "B" shall be plugged in a manner that will provide a solid cement plug through the salt section and prevent liquids or gases from entering the hole above or below the salt section.

VII

LOCATIONS FOR TEST WELLS

Before drilling for oil or gas on lands in Areas "A" or "B", a map or plat showing the location of the proposed well shall be prepared by the well operator and copy sent by registered mail to the potash lessees involved, if any. Upon proper showing of such notice and if no objection to the location of the proposed well is made by the potash lessee within ten days, a drilling permit may be issued and the work may proceed. If, however, the location of the proposed well is objected to by the potash lessee on the grounds that the location of the well is not in accordance with the foregoing regulations, the potash lessee may file a written objection within ten days for consideration and decision by the Oil Conservation Commission.

VIII

INSPECTION OF DRILLING AND MINING OPERATIONS

A representative of the potash lessee may be present during drilling, cementing, casing, and plugging of all oil or gas wells on his lease to observe conformance with these regulations. Likewise, a representative of the oil and gas lessee may inspect mine workings on his lease to observe conformance with these regulations.

IX

FILING OF WELL AND MINE SURVEYS

Each oil and gas lessee shall furnish not later than January 31st of each year to the Oil Conservation Commission and to the potash lessees involved certified directional surveys from the surface to a point below the lowest known potash-bearing horizon for each oil or gas well drilled in Area "A" during the preceding calendar year. Each potash lessee shall furnish not later than January 31st of each year to the Oil Conservation Commission and to each oil and gas lessee involved, certified plat of survey of the location of open mine workings underlying outstanding oil and gas leases.

X

APPLICABILITY OF STATEWIDE RULES AND REGULATIONS

All general statewide rules and regulations of the Oil Conservation Commission governing the development, operation, and production of oil and gas in the State of New Mexico not inconsistent or in conflict herewith, are hereby adopted and made applicable to the areas described herein.

XI

ADOPTION

The foregoing Rules and Regulations are hereby adopted by the Oil Conservation Commission and adopted, ratified and confirmed by the Commissioner of Public Lands of the State of New Mexico this ______ Day of November, 1951.

DONE at Santa Fe, New Mexico this 9th day of November, 1951.

STATE OF NEW MEXICO
OIL CONSERVATION COMMISSION

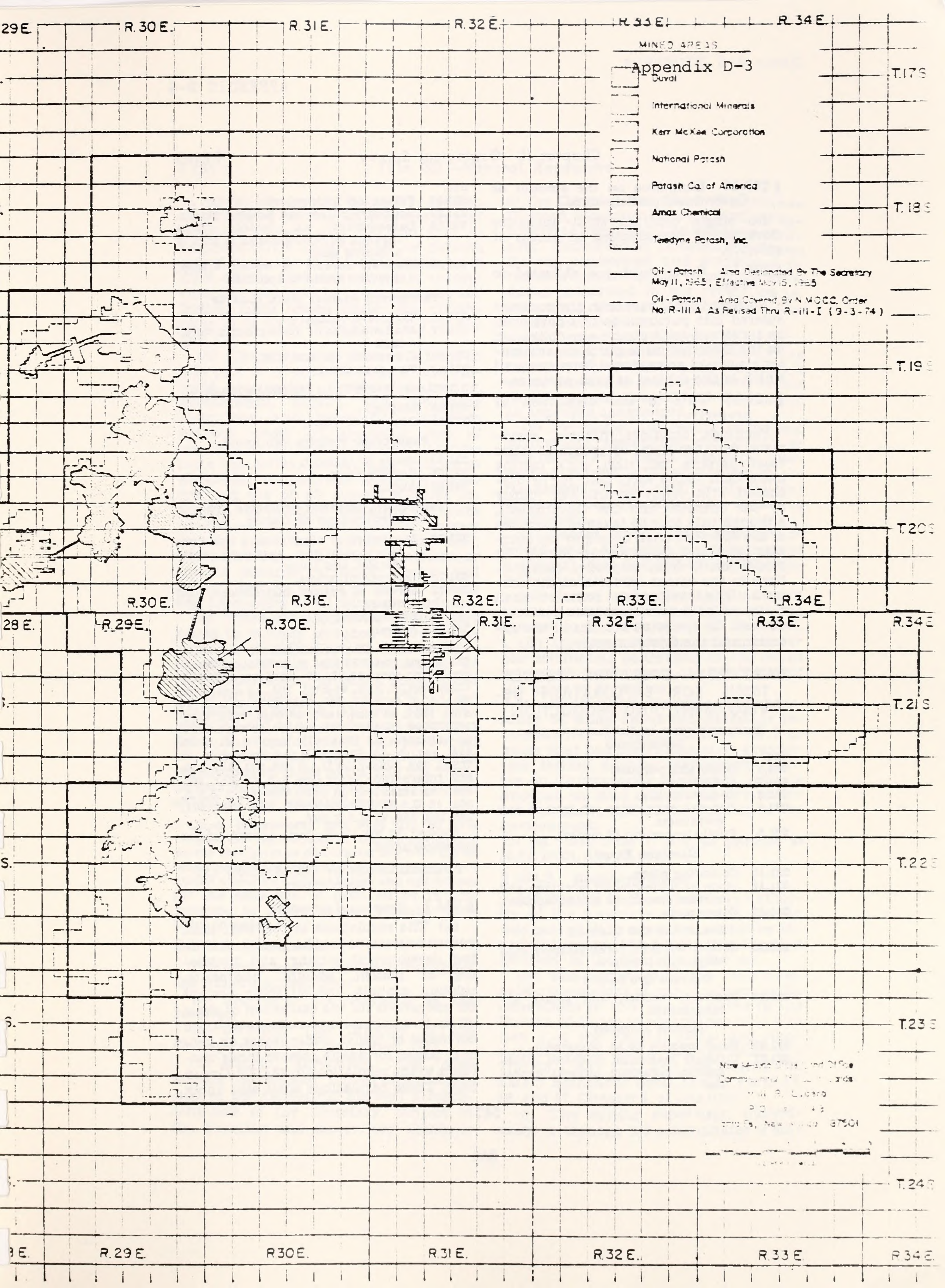
EDWIN L. MECHEM, Chairman

GUY SHEPARD, Member

R. R. SPURRIER, Secretary

____
GUY SHEPARD
Commissioner of Public Lands

Appendix D-3


R.29 E.
R.30 E.
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MINED AREAS
Duval
International Minerals
Kerr McKee Corporation
National Potash
Potash Co. of America
Amax Chemical
Teledyne Potash, Inc.
Oil - Potash Area Designated By The Secretary May 11, 1965, Effective May 15, 1965
Oil - Potash Area Covered By N.M.O.C.C. Order No. R-111 A As Revised Thru R-111-I (9-3-74)
T.17 S.
T.18 S.
T.19 S.
T.20 S.
R.30 E.
R.31 E.
R.32 E.
R.33 E.
R.34 E.
28 E.
R.29 E.
R.30 E.
R.31 E.
R.32 E.
R.33 E.
R.34 E.
T.21 S.
T.22 S.
T.23 S.
New Mexico State Land Office
Commissioner of Public Lands
R. Lucero
P.O.
Fe, New Mexico 87501
T.24 S.
E.
R.29 E.
R30 E.
R.31 E.
R.32 E.
R.33 E.
R.34 E.

§ 229.13 Limitation on the amount of Government participation.

No single contract shall authorize Government participation in excess of $250,000.

§ 229.14 Government not obligated to buy.

Nothing in this part or in any contract entered into pursuant to this part shall be construed as imposing any obligation on the Government to purchase any materials mined or produced from the land which is the subject of such contract.

§ 229.15 Title to and disposition of property.

Facilities, buildings, fixtures, equipment, or other items or groups of items (such as pipe, rail, steel, etc.), costing more than $50.00 each, paid for or purchased with funds contributed jointly by the operator and the Government, although title may be taken in the name of the operator, shall belong to the operator and the Government jointly, in proportion to their respective contributions to the extent set forth in the contract. The exploration contract shall make suitable provisions also for their disposal for the joint account of the operator and the Government.

PART 231—OPERATING REGULATIONS FOR EXPLORATION DEVELOPMENT, AND PRODUCTION

ADMINISTRATION OF REGULATIONS AND DEFINITIONS

Sec.
231.1 Scope and purpose.
231.2 Definitions.
231.3 Responsibilities.
231.4 General obligations of lessees and permittees.
231.5 Public inspection of records.

MAPS AND PLANS

231.10 Operating plans.
231.11 Maps of underground workings and surface operations and equipment.
231.12 Other maps.

BOREHOLES AND SAMPLES

231.20 Core or test hole, cores, samples, cuttings, mill products.

WELFARE AND SAFETY

231.25 Sanitary, welfare, and safety arrangements.

MINING METHODS

231.30 Good practice to be observed.
231.31 Ultimate maximum recovery; information regarding mineral deposits.
Sec.
231.32 Pillars left for support.
231.33 Boundary pillars and isolated blocks.
231.34 Development on leased tracts through adjoining mines as part of a mining unit.
231.35 Minerals soluble in water; brines; minerals taken in solution.

PROTECTION AGAINST MINE HAZARDS

231.40 Surface openings.
231.41 Abandonment of underground workings.
231.42 Flammable gas and dust.
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MILLING; WASTE FROM MINING OR MILLING

231.50 Milling.
231.51 Disposal of waste.

PRODUCTION RECORDS AND AUDIT

231.60 Books of account.
231.61 Royalty basis.
231.62 Audits.

INSPECTION, ISSUANCE OF ORDERS AND ENFORCEMENT OF ORDERS

231.70 Inspection of underground and surface conditions; surveying, estimating, and study.
231.71 Issuance of orders.
231.72 Service of notices, instructions, and orders.
231.73 Enforcement of orders.
231.74 Appeals.

AUTHORITY: The provisions of this Part 231 issued under 35 Stat. 312; 35 Stat. 781, as amended; secs. 32, 6, 26, 41 Stat. 450, 753, 1248; secs. 1, 2, 3, 44 Stat. 301, as amended; secs. 6, 3, 44 Stat. 659, 710; secs. 1, 2, 3, 44 Stat. 1057; 47 Stat. 1487; 49 Stat. 1482, 1250, 1967, 2026; 52 Stat. 347; sec. 10, 53 Stat. 1196, as amended; 56 Stat. 273; sec. 10, 61 Stat. 915; sec. 3, 63 Stat. 683; 64 Stat. 311; 25 U.S.C. 396, 396a–f, 30 U.S.C 189, 271, 281, 293, 359. Interpret or apply secs. 5, 5, 44 Stat. 302, 1058, as amended; 58 Stat. 483–485; 5 U.S.C. 301, 16 U.S.C. 508b, 30 U.S.C. 189, 192c, 271, 281, 293, 359, 43 U.S.C. 387.

SOURCE: 37 FR 11041, June 1, 1972, unless otherwise noted.

ADMINISTRATION OF REGULATIONS AND DEFINITIONS

§ 231.1 Scope and purpose.

(a) The regulations in this part shall govern operations for the discovery, testing, development, mining, and processing of potash, sodium, phosphate, sulphur, asphalt, and oil shale (except for operations for the extraction of shale oil by in situ retorting methods utilizing boreholes or wells) under leases or permits issued for public domain lands pursuant to the regulations in 43 CFR Group 3500. These regulations shall also apply to operations for the discovery, testing, development, mining, and processing of minerals (except coal, oil, and gas) in acquired lands under leases or permits issued pursuant to the regulations in 43 CFR Group 3500 and minerals (except coal, oil, and gas) in tribal and allotted Indian lands leased under the regulations in 25 CFR Parts 171, 172, 173, 174, and 176.

(b) The purpose of the regulations in this part is to promote orderly and efficient prospecting, exploration, testing, development, mining, and processing operations and production practices without waste or avoidable loss of minerals or damage to deposits; to promote the safety, health, and welfare of workmen; to encourage maximum recovery and use of all known mineral resources; to promote operating practices which will avoid, minimize, or correct damage to the environment—land, water and air—and avoid, minimize, or correct hazards to public health and safety; and to obtain a proper record and accounting of all minerals produced.

(c) When the regulations in this part relate to matters included in the regulations in 43 CFR Part 23—Surface Exploration, Mining, and Reclamation of Lands—pertaining to public domain and acquired lands; or 25 CFR Part 177—Surface Exploration, Mining, and Reclamation of Lands—pertaining to Indian lands, the regulations in this part shall be considered as supplemental to the regulations in those parts, and the regulations in those parts shall govern to the extent of any inconsistencies.

Cross Reference: See Part 211 of this chapter for regulations governing operations under coal permits and leases. See Part 221 of this chapter for regulations governing operations under oil and gas leases and operations for the extraction of shale oil by in situ retorting or other methods utilizing boreholes or wells.

§ 231.2 Definitions.

The terms used in this part shall have the following meanings:

(a) *Secretary.* The Secretary of the Interior.

(b) *Director.* The Director of the Geological Survey, Washington, D.C.

(c) *Mining Supervisor.* The Area Mining Supervisor, Conservation Division of the Geological Survey; a representative of the Secretary, subject to the direction and supervisory authority of the Director, the Chief, Conservation Division, Geological Survey, and the appropriate Regional Conservation Manager, Conservation Division, Geological Survey, authorized and empowered to regulate operations and to perform other duties prescribed in the regulations in this part, or any subordinate action under his direction.

(d) *Lessee.* Any person or persons, partnership, association, corporation, or municipality to whom a mineral lease is issued subject to the regulations in this part, or an assignee of such lease under an approved assignment.

(e) *Permittee.* Any person or persons, partnership, association, corporation, or municipality to whom a mineral prospecting permit is issued subject to the regulations in this part, or an assignee of such permit under an approved assignment.

(f) *Leased lands, leased premises, or leased tract.* Any lands or deposits under a mineral lease and subject to the regulations in this part.

(g) *Permit lands.* Any lands or deposit under a mineral prospecting permit and subject to the regulations in this part.

(h) *Operator.* A lessee or permittee or one conducting operations on the leased or permit lands under the authority of the lessee or permittee.

(i) *Reclamation.* The measures undertaken to bring about the necessary reconditioning or restoration of land or water that has been affected by exploration, testing, mineral development, mining, onsite processing operations, or waste disposal, in ways which will prevent or control onsite and offsite damage to the environment.

[37 FR 11041, June 1, 1972, as amended at 38 FR 10001, Apr. 23, 1973]

§ 231.3 Responsibilities.

(a) Subject to the supervisory authority of the Secretary, the regulations in this part shall be administered by the Director through the Chief, Conservation Division, of the Geological Survey.

(b) The responsibility for health and safety inspections of mines subject to the regulations in this part is vested in the Bureau of Mines in accordance with section 4 of the Federal Metal and Nonmetallic Mine Safety Act (80 Stat. 772, 773; 30 U.S.C. 723) and the Health and Safety Standards contained in Parts 55, 56, and 57, Chapter I, of this title.

(c) The mining supervisor, individually, or through his subordinates is empowered to regulate prospecting, exploration, testing, development, mining, and processing operations under the regulations in this part. The duties of the mining supervisor or his subordinates include the following:

(1) *Inspections; supervision of operations to prevent waste or damage.* Examine frequently leased or permit lands where operations for the discovery, testing, development, mining, or processing of minerals are conducted or are to be conducted; inspect and regulate such operations, including operations at accessory plants, for the purpose of preventing waste of mineral substances or damage to formations and deposits containing them, or damage to other formations, deposits, or nonmineral resources affected by the operations, and insuring that the terms and conditions of the permit or lease and the requirements of the exploration or mining plans are being complied with.

(2) *Compliance with regulations, lease or permit terms, and approved plans.* Require operators to conduct their operations in compliance with the provisions of applicable regulations, the terms and conditions of the leases or permits, and the requirements of approved exploration or mining plans.

(3) *Reports on condition of lands and manner of operations; recommendations for protection of property.* Make reports to the Chief, Conservation Division through the Regional Conservation Manager, Conservation Division of Geological Survey, as to the general condition of lands under permit or lease and the manner in which operations are being conducted and orders or instructions are being complied with, and to submit information and recommendations for protecting the minerals, the mineral-bearing formations and the nonmineral resources.

(4) *Manner and form of records, and notices.* Prescribe, subject to the concurrence of the Regional Conservation Manager, Conservation Division, and the approval of the Chief, Conservation Division of the Geological Survey, the manner and form in which records of operations, reports, and notices shall be made.

(5) *Records of production; rentals and royalties.* Obtain and check the records of production of minerals; determine rental and royalty liability of lessees and permittees; collect and deposit rental and royalty payments; and maintain rental and royalty accounts.

(6) *Suspension of operations and production.* Act on applications for suspension of operations or production or both filed pursuant to 43 CFR 3503.3-2(e), and terminate such suspensions which have been granted; and transmit to the Bureau of Indian Affairs for appropriate action applications for suspension of operations or production or both under leases on Indian lands.

(7) *Cessation and abandonment of operations.* Upon receipt of a report of cessation or abandonment of operations, inspect and determine whether the terms and conditions of the permit or lease and the exploration or mining plans have been complied with; and determine and report to the agency having administrative jurisdiction over the lands when the lands have been properly conditioned for abandonment. The mining supervisor, in accordance with applicable regulations, will consult with, or obtain the concurrence of, the authorized officer of the agency having administrative jurisdiction over the lands with respect to compliance by the operator with the surface protection and reclamation requirements of the lease or permit and the exploration or mining plan.

(8) *Trespass involving removal of mineral deposits.* Report to the agency having administrative jurisdiction over the lands any trespass that involves removal of mineral deposits.

(d) Prior to the approval of an exploration or mining plan, the mining supervisor shall consult with the authorized officer of the agency having administrative jurisdiction over the lands with respect to the surface protection and reclamation aspects of the plan.

(e) The mining supervisor shall inspect exploratory and mining operations to determine the adequacy of water management and pollution control measures for the protection and control of the quality of surface and ground water resources and the adequacy of emission control measures for the protection and control of air quality.

(f) The mining supervisor shall issue such orders and instructions not in conflict with the laws of the State in which the leased or permit lands are situated as necessary to assure compliance with the purposes of the regulations in this part.

(g) In the exercise of his jurisdiction under the regulations in this part, the mining supervisor shall be subject to the direction and supervisory authority of the Chief, Conservation Division, and the appropriate Regional Conservation Manager, Conservation Division of the Geological Survey, each of whom may exercise the jurisdiction of the mining supervisor.

[37 FR 11041, June 1, 1972, as amended at 38 FR 10001, Apr. 23, 1973]

§ 231.4 General obligations of lessees and permittees.

(a) Operations for the discovery, testing, development, mining, or processing of minerals shall conform to the provisions of applicable regulations, the terms and conditions of the lease or permit, the requirements of approved exploration or mining plans, and the orders and instructions issued by the mining supervisor or his subordinates under the regulations in this part. Lessees and permittees shall take precautions to prevent waste and damage to mineral-bearing formations, and shall take such steps as may be needed to prevent injury to life or health and to provide for the health and welfare of employees.

(b) Lessees and permittees shall take such action as may be needed to avoid, minimize, or repair soil erosion; pollution of air; pollution of surface or ground water; damage to vegetative growth, crops, including privately owned forage, or timber; injury or destruction of fish and wildlife and their habitat; creation of unsafe or hazardous conditions; and damage to improvements, whether owned by United States, its permittees, licensees or lessees, or by others; and damage to recreational, scenic, historical, and ecological values of the land. The surface of leased or permit lands shall be reclaimed in accordance with the terms and conditions prescribed in the lease or permit and the provisions of the approved exploration or mining plan. Where any question arises as to the necessity for or the adequacy of an action to meet the requirements of this paragraph, the determination of the mining supervisor shall be final subject to the right of appeal as provided in part 290 of this chapter.

(c) All operations conducted under the regulations in this part must be consistent with Federal and State water and air quality standards.

(d) When the mining supervisor determines that a water pollution problem exists, the mining supervisor may require that a lessee or permittee maintain records of the use of water, quantity and quality of waste water produced, and the quantity and quality of waste water disposal, including mine drainage discharge, process wastes and associated wastes. In order to obtain this information, the lessee or permittee may be required to install a suitable monitoring system.

(e) Full reports of accidents, inundations, or fires shall be promptly mailed to the mining supervisor by the operator or his representative. Fatal accidents, accidents threatening damage to the mine, the lands, or the deposits, or accidents which could cause water pollution shall be reported promptly to the mining supervisor by telegram or telephone. The reports required by this section shall be in addition to those required by Parts 55, 56, or 57, Chapter I of this title or other applicable regulations.

(f) Lessees and permittees shall submit the reports required by 25 CFR Part 177; Part 200 of this chapter, and 43 CFR Part 23.

[37 FR 11041, June 1, 1972, as amended at 38 FR 10001, Apr. 23, 1973]

§ 231.5 Public inspection of records.

Geological and geophysical interpretations, maps, and data and commercial and financial information required to be submitted under this part shall not be available for public inspection without the consent of the permittee or lessee so long as the permittee or lessee furnishing such data, or his successors or assignees, continues to hold a permit or lease of the lands involved.

MAPS AND PLANS

§ 231.10 Operating plans.

(a) *General.* Before conducting any operations under a permit or lease, the operator shall submit, in quintuplicate, to the mining supervisor for approval an exploration or mining plan which shall show in detail the proposed exploration, prospecting, testing, development, or mining operations to be conducted. Exploration and mining plans shall be consistent with and responsive to the requirements of the lease or permit for the protection of nonmineral resources and for the reclamation of the surface of the lands affected by the operations. The mining supervisor shall consult with the other agencies involved, and shall promptly approve the plans or indicate that modifications of the plans are necessary to conform to the provisions of the applicable regulations and the terms and conditions of the permit or lease. No operations shall be conducted except under an approved plan.

(b) *Exploration plans.* The mining supervisor may require that an exploration plan include any or all of the following:

(1) A description of the area within which exploration is to be conducted;

(2) Five copies of a suitable map or aerial photograph showing topographic, cultural, and drainage features;

(3) A statement of proposed exploration methods, i.e., drilling, trenching, etc., and the location of primary support roads and facilities;

(4) A description of measures to be taken to prevent or control fire, soil erosion, pollution of surface and ground water, pollution of air, damage to fish and wildlife or other natural resources, and hazards to public health and safety both during and upon abandonment of exploration activities.

(c) *Mining plans.* The mining supervisor may require that a mining plan include any or all of the following:

(1) A description of the location and area to be affected by the operations;

(2) Five copies of a suitable map, or aerial photograph showing the topography, the area covered by the permit or lease, the name and location of major topographic and cultural features, and the drainage plan away from the area affected;

(3) A statement of proposed methods of operating, including a description of the surface or underground mining methods; the proposed roads or vehicular trails; the size and location of structures and facilities to be built;

(4) An estimate of the quantity of water to be used and pollutants that are expected to enter any receiving waters;

(5) A design for the necessary impoundment, treatment or control of all runoff water and drainage from workings so as to reduce soil erosion and sedimentation and to prevent the pollution of receiving waters;

(6) A description of measures to be taken to prevent or control fire, soil erosion, pollution of surface and ground water, pollution of air, damage to fish and wildlife or other natural resources, and hazards to public health and safety;

(7) A statement of the proposed manner and time of performance of work to reclaim areas disturbed by the operations.

(d) *Revegetation; regrading; backfilling.* In those instances in which the permit or lease requires the revegetation of an area to be affected by operations the exploration or mining plan shall show:

(1) Proposed methods of preparation and fertilizing the soil prior to replanting;

(2) Types and mixtures of shrubs, trees, or tree seedlings, grasses or legumes to be planted; and

(3) Types and methods of planting, including the amount of grasses or legumes per acre, or the number and spacing of trees, or tree seedlings, or combinations of grasses and trees.

If the permit or lease requires regrading and backfilling, the exploration or mining plan shall show the proposed methods and the timing of grading and backfilling of areas of lands affected by the operations.

(e) *Changes in plans.* Exploration and mining plans may be changed by mutual consent of the mining supervisor and the operator at any time to adjust to changed conditions or to correct an oversight. To obtain approval of a changed or supplemental plan the operator shall submit a written statement of the proposed changes or supplement and the justification for the changes proposed.

(f) *Partial plan.* If circumstances warrant, or if development of an exploration or mining plan for the entire operation is dependent upon unknown factors which cannot or will not be determined except during the progress of the operations, a partial plan may be approved and supplemented from time to time. The operator shall not, however, perform any operation except under an approved plan.

§ 231.11 Maps of underground workings and surface operations and equipment.

Maps of underground workings and surface operations shall be drawn to a scale acceptable to the mining supervisor. All maps shall be appropriately marked with reference to Government land marks or lines and elevations with reference to sea level. When required by the mining supervisor vertical projections and cross sections shall accompany plan views. Maps shall be based on accurate surveys made at least annually and as may be necessary at other times. Accurate copies of such maps on reproducible material or prints thereof shall be furnished the mining supervisor when and as required. The maps shall be posted to date and submitted to the mining supervisor at least once each year. The accuracy of maps furnished shall be certified by a professional engineer, professional land surveyor, or other professionally qualified person.

§ 231.12 Other maps.

(a) The operator shall prepare such maps of the leased lands as in the judgment of the mining supervisor are necessary to show the surface boundaries, improvements, and topography, including subsidence resulting from mining, and the geological conditions so far as determined from outcrops, drill holes, exploration or mining. All excavations in each separate bed or deposit shall be shown in such manner that the production of minerals for any royalty period can be accurately ascertained.

(b) In the event of the failure of the operator to furnish the maps required, the mining supervisor shall employ a competent mine surveyor to make a survey and maps of the mine, and the cost thereof shall be charged to and promptly paid by the operator.

(c) If any map submitted by an operator is believed to be incorrect, the mining supervisor may cause a survey to be made, and if the survey shows the map submitted by the operator to be substantially incorrect in whole or in part, the cost of making the survey and preparing the map shall be charged to and promptly paid by the operator.

BORE HOLES AND SAMPLES

§ 231.20 Core or test hole, cores, samples, cuttings, mill products.

(a) The operator shall submit promptly to the mining supervisor signed copies, in duplicate, of records of all core or test holes made on the leased or permit lands, the records to be in such form that the position and direction of the holes can be accurately located on a map. The records shall include a log of all strata penetrated and conditions encountered, such as water, quicksand, gas, or unusual conditions, and copies of analyses of all samples analyzed from strata penetrated shall be transmitted to the mining supervisor as soon as obtained or at such time as specified by the mining supervisor. All drill holes will be logged under supervision of a competent geologist or engineer, and the lessees will furnish to the mining supervisor a detailed lithologic log of each drill hole and all other in-hole surveys, such as electric logs, gamma ray neutron logs, sonic logs or any other logs produced. The core from test holes shall be retained by the operator for 1 year and shall be available for inspection at the convenience of the mining supervisor, and he shall be privileged to cut such cores and receive samples of such parts as he may deem advisable, or on request of the mining supervisor the operator shall furnish such samples of strata, drill cuttings, and mill products as may be required.

(b) Drill holes for development or holes for prospecting shall be abandoned to the satisfaction of the mining supervisor by cementing and/or casing or by other methods approved in advance by the mining supervisor and in a manner to protect the surface and not to endanger any present or future underground operation or any deposit of oil, gas, other mineral substances, or water strata.

(c) At the option of the mining supervisor or the operator drill holes may be converted to surveillance wells for the purpose of determining the effect of subsequent operations upon the quantity, quality, or pressure of ground water or mine gases.

(d) When drilling on lands valuable or potentially valuable for oil and gas or geothermal resources drilling equipment shall be equipped with blowout control devices acceptable to the mining supervisor before penetrating more than 100 feet of consolidated sediments unless a greater depth is approved in advance by the mining supervisor.

WELFARE AND SAFETY

§ 231.25 Sanitary, welfare, and safety arrangements.

The underground and surface sanitary, welfare, health, and safety arrangements shall be in accordance with the recommendations of the U.S. Public Health Service and the applicable standards in Parts 55, 56, and 57, Chapter I of this title.

CROSS REFERENCE: For regulations of the U.S. Public Health Service, Department of Health, Education, and Welfare, see 42 CFR Chapter I.

MINING METHODS

§ 231.30 Good practice to be observed.

The operator shall observe good practice following the highest standards in prospecting, exploration, testing, development, and mining, sinking wells, shafts, and winzes, driving drifts and tunnels, stoping, blasting, transporting ore and materials, hoisting, the use of explosives, timbering, pumping, and other activities on the leased or permit lands.

§ 231.31 Ultimate maximum recovery; information regarding mineral deposits.

(a) Mining operations shall be conducted in a manner to yield the ultimate maximum recovery of the mineral deposits, consistent with the protection and use of other natural resources and the protection and preservation of the environment—land, water, and air. All shafts, main exits, and passageways, as well as overlying beds or mineral deposits that at a future date may be of economic importance, shall be protected by adequate pillars in the deposit being worked or by such other means as approved by the mining supervisor.

(b) Information obtained regarding the mineral deposit being worked and other mineral deposits on the leased or permit lands shall be fully recorded and a copy of the record furnished to the mining supervisor.

§ 231.32 Pillars left for support.

Sufficient pillars shall be left in first mining to insure the ultimate maximum recovery of mineral deposits when the time arrives for the removal of pillars. Boundary pillars shall in no case be less than 50 feet thick unless otherwise specified in writing by the mining supervisor. Boundary and other main pillars shall be mined only with the written consent or by order of the mining supervisor or his authorized subordinates.

§ 231.33 Boundary pillars and isolated blocks.

(a) If the ore on adjacent lands subject to these regulations has been worked out beyond any boundary pillar, if the water level beyond the pillar is below the lessee's adjacent operations, and if no other hazards exist, the lessee shall, on the written demand of the mining supervisor, mine out and remove all available ore in such boundary pillar, both in the lands covered by the lease and in the adjoining premises, when the mining supervisor determines that it can be mined without undue hardship to the lessee.

(b) If the mining rights in adjoining premises are privately owned or controlled, an agreement may be made with the owners of such interests for the extraction of the ore in the boundary pillars.

(c) Narrow strips of ore between leased lands and the outcrop on other lands subject to these regulations and small blocks of ore adjacent to leased lands that would otherwise be isolated or lost may be mined under the provisions specified in paragraphs (a) and (b) of this section.

§ 231.34 Development on leased tract through adjoining mines as part of a mining unit.

A lessee may mine his leased tract from an adjoining underground mine on land privately owned or controlled or from adjacent leased lands, under the following conditions:

(a) A mine that is on the land privately owned or controlled shall conform to all sections in the regulations in this part.

(b) The only connections between the mine on land privately owned or controlled and the mine on leased land shall be the main haulageways, the ventilationways, and the escapeways. Substantial concrete frames and fireproof doors that may be closed in an emergency and opened from either side shall be installed in each such connection. Other connections through the boundary pillars shall not be made until both mines are about to be exhausted and abandoned. The mining supervisor may waive any of the requirements in this paragraph when, in his judgment, such a waiver would not conflict with the regulations in Part 57, Chapter I of this title and would not entail substantial loss of ore.

(c) Free access for inspection of said connecting mine on land privately owned or controlled shall be given at any reasonable time to the mining supervisor or other representative of the Secretary of the Interior.

(d) If a lessee operating on a lease through a mine on land privately owned or controlled does not maintain the mine in accordance with the operating regulations, operations on the leased land may be ordered stopped or departmental seals applied by the mining supervisor.

and the operations on leased lands shall be stopped.

§ 231.35 Minerals soluble in water; brines; mineral taken in solution.

In mining or prospecting deposits of potassium or other minerals soluble in water, all wells, shafts, prospect holes, and other openings shall be adequately protected with neat cement or other suitable materials against the coursing or entrance of water; and the operator shall, on orders of the mining supervisor, backfill with rock or other suitable material to protect the roof from breakage when there is a danger of the entrance of water. On leased or permit lands containing brines, due precaution shall be exercised to prevent the deposits becoming diluted or contaminated by the mixture of water or valueless solution. Where minerals are taken from the earth in solution, such extraction shall not be within 500 feet of the boundary line of the leased lands without the written permission of the mining supervisor.

PROTECTION AGAINST MINE HAZARDS

§ 231.40 Surface openings.

(a) The operator shall substantially fill in, fence, protect or close all surface openings, subsidence holes, surface excavations or workings which are a hazard to people or animals. Such protective measures shall be maintained in a secure condition during the term of the permit or lease. Before abandonment of operations all openings, including water discharge points, shall be closed to the satisfaction of the mining supervisor.

(b) Reclamation or protection of surface areas no longer needed for operations should commence without delay. The mining supervisor shall designate such areas where restoration or protective measures, or both, must be taken.

§ 231.41 Abandonment of underground workings.

No underground workings or part thereof shall be permanently abandoned and rendered inaccessible without the advance and written approval of the mining supervisor.

§ 231.42 Flammable gas and dust.

Mines in which flammable gas is found or explosive dust produced shall be subject to the coal-mining operating regulations in Part 211 of this chapter. An "explosive dust" is a combustible solid in airborne dispersion capable of propagating flame when ignited.

§ 231.43 Fire protection.

All structures within 100 feet of any mine opening shall be protected against fire and constructed of fire resistant material. Flammable material shall not be stored within 100 feet of a mine exit. All shafts shall be fireproof, or adequate fire-control devices, satisfactory to the mining supervisor, shall be installed. All underground offices, stations, shops, magazines, and stores shall be so constructed, equipped, and maintained as to reduce the fire hazard to a minimum. Sufficient fire-fighting apparatus shall be maintained in working condition at the mine exits and at convenient points in the mine workings for fire emergencies. An adequate water supply shall be held in storage tanks or reservoirs for fire emergencies and shall be available for immediate use through connecting pipelines for either surface or underground fires.

MILLING; WASTE FROM MINING OR MILLING

§ 231.50 Milling.

It shall be the duty of the operator to conduct milling operations pursuant to the terms of the lease, the approved mining plan, and the regulations in this part and to use due diligence in the reduction, concentration, or separation of mineral substances by mechanical or chemical processes, by distillation, by evaporation, or other means so that the percentage of salts, concentrates, oil, or other mineral substances recovered shall be in accordance with approved practices.

§ 231.51 Disposal of waste.

The operator shall dispose of all wastes resulting from the mining, reduction, concentration, or separation of mineral substances in accordance with the terms of the lease, approved mining plan, the regulations in this part, and the directions of the mining supervisor.

PRODUCTION RECORDS AND AUDIT

§ 231.60 Books of account.

Operators shall maintain books in which will be kept a correct account of all ore and rock mined, of all ore put through the mill, of all mineral products produced, and of all ore and mineral products sold and to whom sold, the weight, assay value, moisture content, base price, dates, penalties, and price received, and the percentage of the mineral products recovered and lost shall be shown.

CROSS REFERENCE: See Part 200 of this chapter for reports required to be filed and the forms to be used.

§ 231.61 Royalty basis.

The sale price basis for the determination of the rates and amount of royalty shall not be less than the highest and best obtainable market price of the ore and mineral products, at the usual and customary place of disposing of them at the time of sale, and the right is reserved to the Secretary of the Interior to determine and declare such market price, if it is deemed necessary by him to do so for the protection of the interests of the lessor.

§ 231.62 Audits.

An audit of the lessee's accounts and books may be made annually or at such other times as may be directed by the mining supervisor, by certified public accountants, and at the expense of the lessee. The lessee shall furnish free of cost duplicate copies of such annual or other audits to the mining supervisor, within 30 days after the completion of each auditing.

INSPECTION, ISSUANCE OR ORDERS, AND ENFORCEMENT OF ORDERS

§ 231.70 Inspection of underground and surface conditions; surveying, estimating, and study.

Operators shall provide means at all reasonable hours, either day or night, for the mining supervisor or his representative to inspect or investigate the underground and surface conditions; to conduct surveys; to estimate the amount of ore or mineral product mined; to study the methods of prospecting, exploration, testing, development, processing, and handling that are followed; to determine the volumes, types, and composition of wastes generated, the adequacy of measures for minimizing the amount of such wastes, and the measures for treatment and disposal of such wastes; and to determine whether the terms and conditions of the permit or lease and the requirements of the exploration or mining plan have been complied with.

§ 231.71 Issuance of orders.

Before beginning operations the operator shall inform the mining supervisor in writing of the designation and post office address of the exploration or mining operation, the operator's temporary and permanent post office address, and the name and post office address of the superintendent or other agent who will be in charge of the operations and who will act as the local representative of the operator. The mining supervisor shall also be informed of each change thereafter in the address of the mine office or in the name or address of the local representative.

§ 231.72 Service of notices, instructions, and orders.

The operator shall be considered to have received all notices, instructions, and orders that are mailed to or posted at the mine or mine office, or mailed or handed to the superintendent, the mine foreman, the mine clerk, or higher officials connected with the mine, for transmittal to the operator or his local representative.

§ 231.73 Enforcement of orders.

(a) If the mining supervisor determines that an operator has failed to comply with the regulations in this part, other applicable departmental regulation, the terms and conditions of the permit or lease, the requirements of an approved exploration or mining plan, or with the mining supervisor's orders or instructions, and such noncompliance does not threaten immediate, serious, or irreparable damage to the environment, the mine or the deposit being mined, or other valuable mineral deposits or other resources, the mining supervisor shall serve a notice of noncompliance upon the operator by delivery in person to him or his agent or by certified or registered mail addressed to the operator at his last known address. Failure of the operator to take action in accordance with the notice of noncompliance shall be grounds for suspension by the mining supervisor of operations.

(b) A notice of noncompliance shall specify in what respects the operator has failed to comply with the provisions of applicable regulations, the terms and conditions of the permit or lease, the requirements of an approved exploration or mining plan or the orders and instructions of the mining supervisor, and shall specify the action which must be taken to correct the noncompliance and the time limits within which such action must be taken.

(c) If in the judgment of the mining supervisor such failure to comply with the regulations, the terms and conditions of the permit or lease, the requirements of approved exploration or mining plans, or with the mining supervisor's orders or instructions threatens immediate, serious, or irreparable damage to the environment, the mine or the deposit being mined, or other valuable mineral deposits or other resources, the mining supervisor is authorized, either in writing or orally with written confirmation, to suspend operations without prior notice.

§ 231.74 Appeals.

Orders or decisions issued under the regulations in this part may be appealed as provided in part 290 of this chapter.

[38 FR 10001, Apr. 23, 1973]

Cross Reference: See 43 CFR 23.12 for appeals under 43 CFR Part 23—Surface Exploration, Mining, and Reclamation of Lands. See 25 CFR 177.11 for appeals under 25 CFR Part 177—Surface Exploration, Mining, and Reclamation of Lands.

PART 241—ACQUISITION AND LEASING OF WATER WELLS

Sec.
241.1 Secretary of the Interior may take over, purchase casing in, and condition wells for water production.
241.2 Wells drilled prior to or after act of June 16, 1934 under premits issued prior to said act; development of water in wells drilled by persons not in privity with permittees or lessees.
241.3 Provisions of act of June 16, 1934; where inapplicable.
241.4 Federal oil and gas supervisor to submit report before approving notice of intention to abandon any well not excluded in § 241.3.
241.5 Geological Survey to determine value of water.
241.6 Application for, and award of lease to, water well.
241.7 Funds available for plugging and abandonment, available for conditioning, maintenence and development of water supplies.

Authority: The provisions of this Part 241 issued under sec. 32, 41 Stat. 450, sec. 40, 48 Stat. 977; 30 U.S.C. 189, 229a.

Source: The provisions of this Part 241 contained in Regulations, Oct. 23, 1934, unless otherwise noted.

Cross Reference: For Bureau of Land Management regulations relating to water reserves, see 43 CFR Subpart 2311.

§ 241.1 Secretary of the Interior may take over, purchase casing in, and condition wells for water production.

Under the provisions of the act of June 16, 1934 (48 Stat. 977; 30 U.S.C. 229a), amending the act of February 25, 1920 (41 Stat. 441–445; 30 U.S.C. 221, 222–223), all oil and gas permits and leases issued after June 16, 1934, are subject to the authority of the Secretary of the Interior to take over, purchase necessary casing in, and condition for water production any well drilled which strikes water of value for any of the uses named in the act: *Provided*, That the taking over of such well will not restrict operations under the permit or lease.

§ 241.2 Wells drilled prior to or after act of June 16, 1934 under permits issued prior to said act; development of water in wells drilled by persons not in privity with permittees or lessees.

The Secretary of the Interior may also take over and condition wells heretofore or hereafter drilled under permits and leases previously issued, and may develop water in any wells plugged or abandoned or wells drilled prior to the issuance of permits or leases by persons not in privity with the permittees or lessees.

§ 241.3 Provisions of act of June 16, 1934; where inapplicable.

The provisions of this act do not apply to wells drilled on lands entered or patented under any of the public land laws with reservation of the oil and gas deposits since any water developed in such lands does not belong to the United States.

§ 241.4 Federal oil and gas supervisor to submit report before approving notice of intention to abandon any well not excluded in § 241.3.

Before approving any notice of intention to abandon any well on land not excluded in § 241.3, which well is known or believed to contain water of such quality and quantity as to be valuable and usable at a reasonable cost for agricultural, domestic, or other purposes, the Federal oil and gas supervisor having jurisdiction will submit a report to the Director of the Geological Survey, containing information as to the location of the well by legal subdivision of the public land survey, the depth to water, the yield, if determinable, the suitability of the water for irrigation,

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Appendix D-5

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

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STATE OFFICE
SANTA FE, NEW MEXICO

October 6, 1972

ORDER NO. 2948

Subject: Division of Responsibility Between the Bureau of Land Management and the Geological Survey for Administration of the Mineral Leasing Laws - Onshore

Sec. 1. Purpose. The purpose of this Order is to set forth the administrative and management procedures for Departmental onshore mineral leasing and operating activities. The spirit and intent of this Order flow from the Department's mineral management objectives of: orderly and timely resources development, protection of the environment, and receipt of fair market value for leased mineral resources.

Sec. 1(a) Orderly and Timely Resource Development includes the Department's responsibilities to:

(1) Foster, promote, and encourage the exploration for and the production of the mineral deposits from the leasable lands; promote competition;

(2) Encourage the active development of the mineral deposits in the leasable lands in a manner compatible with the use of the same lands for other purposes; assure that mineral developers receive the acreage necessary for economic plant investment, development, and production;

(3) Encourage the maximum ultimate recovery of the mineral deposit; prevent waste; promote the conservation of the mineral resources;

(4) Assure adequate minimum production and diligent development requirements for mineral deposits.

(b) Protection of the Environment includes the Department's responsibilities to:

(1) Assure that mineral exploration and production be conducted with the maximum protection of the environment;

(2) Assure the rehabilitation of disturbed lands;

(3) Assure that precautions are taken to protect public health and safety; and

(4) Assure full compliance with the spirit and objectives of the National Environmental Policy Act of 1969, other Federal environmental legislation, and supporting Executive Orders and regulations.

(c) Receipt of Fair Market Value for Leased Mineral Resources includes the Department's responsibilities to assure the public a fair market value return for the use of public lands and the disposition of its mineral resources.

Sec. 2. Agency Responsibilities. The BLM exercises at the Bureau level the Secretary's discretionary authority to determine whether or not leases, permits, and licenses are to be issued. The Bureau of Land Management is responsible for issuing mineral leases, permits, and licenses, and is the office of record in mineral leasing matters. The Geological Survey is responsible for all geologic, engineering, and economic value determinations for the Department's mineral management program. These determinations include: the mineral characteristics of lease and permit areas; parcelling; amounts of bonds; royalties; unit values; rentals; mineral resource evaluations; reserves; investment, diligent development, and minimum production requirements; and all other terms and conditions relating to mineral operations under leases and permits. Geological Survey exercises the Secretary's delegated authority regarding operations conducted within the area of operation by permittees, lessees, and licensees and determines the actions to be taken by them from the standpoint of the development, conservation, and management of mineral resources under the jurisdiction of the Department. GS will refer to BLM any instances of noncompliance with lease terms requiring cancellation action, and BLM will inititate the necessary action.

For the purpose of this Order, the area of operation is defined as that area of the present and planned mine, oil and gas field, or geothermal resource field exploratory, development, and production operations, as presented in an approved exploration or mining plan, drilling permit, oil, gas, or geothermal field development plan, or plan for the abandonment of wells or operations. The area of operation may cover a fraction of a lease or permit area, or it may cover several lease or permit areas. It encompasses the general area needed for storage piles, spoils piles, tailings ponds, on-project mill sites, flow lines, separators, surge tanks, storage tanks, on-project truck or rail-loading stations, drill pads, mud pits, workshops, compressors, generators, on-project power plants, and other such facilities used for on-project mine, oil and gas field, or geothermal resource field exploratory, development, and production operations.

(a) Environmental Protection. The Bureau of Land Management, in cooperation with the Geological Survey, formulates the general requirements to be incorporated in leases, permits, and licenses for the protection of the surface and non-mineral resources and for reclamation. The Geological Survey, before approving exploration and mining plans, drilling permits, oil, gas, or geothermal field development plans, or plans for the abandonment of wells or operations, consults with the Bureau of Land Management on the adequacy of the surface use, environmental protection, and reclamation aspects of the plans and will not grant approval if inconsistent with the BLM's recommendations without further discussions with BLM. If differences remain after these further discussions, the resolution is made by the Assistant Secretary--Mineral Resources and the Assistant Secretary--Public Land Management. If required, the Under Secretary resolves any remaining differences. The BLM is responsible for compliance examinations of environmental protection requirements outside the operating area and for reporting infractions to the GS for discussions with, or orders to, the permittee, lessee, or licensee. GS examines operations to ensure compliance with environmental protection and rehabilitation requirements inside the operating area. With respect to approval of access roads, pipelines, utility routes and other surface uses outside the operating area, the Bureau of Land Management has the primary responsibility but obtains the recommendations of the Geological Survey before taking final action. Orders to operators for any remedial action is the responsibility of the Geological Survey.

(b) Expertise. The Geological Survey is responsible for maintaining engineering, geologic, geophysical, economic, and other technical expertise needed by the Department to assure compliance with applicable laws, operating regulations, and the objectives of the Department's mineral management program. The Bureau of Land Management is responsible for maintaining expertise needed by the Department for action on applications filed with BLM under the mineral leasing laws to assure compliance with applicable laws, leasing regulations, and the objectives of the Department's mineral management program.

(c) Contacts with Applicants.

(1) Prior to the issuance of mineral leases, permits, and licenses, the Bureau of Land Management will represent the Secretary in dealing with applicants.

(2) After issuance and during the exploration, development, and production phases of leases, permits, and licenses, and until a lease, permit, or license has terminated (at which time management is the sole responsibility of BLM) the Geological Survey is the sole representative of the Secretary in all matters relating to the supervision of operations.

Sec. 3. Issuance of Mineral Leases, Permits, and Licenses.

(a) Applications. Prior to the issuance of mineral prospecting permits, leases, or licenses, the Bureau of Land Management refers all applications for such permits, leases, or licenses to the Geological Survey for a report as outlined in (b) below.

(1) The Geological Survey is responsible for determining, under the mineral leasing laws and regulations, if sufficient information is known about a mineral deposit to warrant offering the deposit for lease by competitive sale and to notify the Bureau of Land Management of its determination. If the Geological Survey finds that sufficient information is not available to warrant competitive leasing, it notifies the Bureau of Land Management of its conclusions so that the Bureau of Land Management may issue a prospecting permit or noncompetitive lease, as appropriate. The Geological Survey establishes prospecting requirements for prospecting permits. When lands are to be leased, the Geological Survey determines and reports, as appropriate, on: the mineral characteristics of lease and permit areas; parcelling; amounts of bonds; royalties; unit values; rentals; mineral resource evaluations; reserves; investments; diligent development and minimum production requirements; and all other terms and conditions pertaining to lease operations, including environmental and surface rehabilitation stipulations relating to mineral exploration and extraction. With respect to applications for licenses, the Geological Survey determines and reports as to whether the license may be issued.

(2) The Geological Survey is responsible for determining whether a prospecting permittee has demonstrated that the lands contain a mineral deposit having the characteristics required by law and regulations to qualify for a preference right lease and to notify the Bureau of Land Management.

(3) The Bureau of Land Management refers to the Geological Survey all other type applications received which, if approved, may affect operations on existing permits, leases, or licenses.

(4) The Bureau of Land Management notifies the Geological Survey of known oil, gas, and geothermal resource geophysical exploration activity, including the area involved, the type of survey employed, and the name of the operator.

(5) All applications for noncompetitive oil and gas, mineral, and geothermal resource leases filed with the Bureau of Land Management will, prior to issuance of a lease, be referred to the Geological Survey for a determination as to whether the lands are within a known geologic structure (KGS), a known geothermal resource area (KGRA), or a known leasing area (KLA).

(b) Mineral Resource Evaluation Report. GS is responsible for submitting a report of its findings, mineral resource evaluations, and resultant recommendations to the BLM, together with a summary explanation of how the resource evaluations were developed from geophysical, geologic, economic, and engineering data available at the time of the evaluation. The BLM reviews these findings and recommendations in light of multiple-use management requirements and will not issue leases or permits inconsistent with the findings and recommendations without further discussion with GS. If differences remain after further discussion, the resolution is made by the Assistant Secretary--Mineral Resources and the Assistant Secretary--Public Land Management. If required, the Under Secretary resolves any remaining differences.

(c) Competitive Lease Sales. The Bureau of Land Management advertises and conducts competitive lease sales. The Geological Survey's resource evaluations will be used and the Geological Survey will have representatives at the sale and renders a post-sale recommendation to BLM regarding acceptance or rejection of the bids, which must be confirmed in writing.

(d) Files and Records. BLM maintains the official application, permit, and lease case files and forwards to the Geological Survey a copy of each permit, lease, and license, together with copies of relevant correspondence thereafter conducted by the Bureau. The GS forwards to the BLM copies of mining and exploration plan applications, drilling permit applications, and relevant items submitted by the applicants directly to the GS, except confidential proprietary information cited under paragraph (e) below.

(e) Security of Information. The Geological Survey is responsible for receiving and protecting for the confidential use of the Federal Government all proprietary geological, geophysical, engineering, economic, statistical, or other information, mineral resource data, and well logs required to be submitted under Title 30 CFR, Parts 200, 211, 216, 221, 231, 270, and related regulations. The Survey Office receiving such information is designated the Office of Control for those data. Authorized officials of BLM or other surface-managing agencies having a need to see such information will normally make appropriate arrangements to visit the Office of Control for access to such data and for technical advice based on it pertinent to their management responsibilities.

Sec. 4. Mineral Reports. The Geological Survey is responsible for preparing and submitting to the Bureau of Land Management mineral classification and evaluation reports with respect to the leasable mineral value of lands within proposed exchanges, withdrawals, sales, land entries, or other disposals and all other land transactions. The Geological Survey, upon request, also prepares and furnishes mineral reports and other information to the Bureau of Land Management needed for its use in long-range multiple-use planning or inventory of the public lands.

Sec. 5. General Relationships. Such additional references, reports, interchange of information, and advice shall be made by or between the Bureau of Land Management and Geological Survey as may be necessary to perpetuate or improve current practice and provide effective administration of the mineral leasing laws.

The Bureau of Land Management and the Geological Survey must submit to each other for review and recommendations any proposed changes in standard lease terms, regulations, instructions, or other changes that would affect each agency's management responsibilities.

Sec. 6. Implementation of Order. It is intended that there will be no duplication by the BLM or GS of the functions assigned by this Order. BLM and GS will promptly bring their manuals and instructions into agreement with the terms and the spirit and intent of this Order.

Sec. 7. Revocation. The Secretary's instruction (procedures relating to the administration of the mineral leasing laws - General Land Office and Geological Survey) dated September 22, 1925 (51 L. D. 219) is revoked.

OCT - 6 1972

Secretary of the Interior

Appendix D-6

Executive Order 11514

PROTECTION AND ENHANCEMENT OF ENVIRONMENTAL QUALITY

By virtue of the authority vested in me as President of the United States and in furtherance of the purpose and policy of the National Environmental Policy Act of 1969 (Public Law No. 91-190, approved January 1, 1970), it is ordered as follows:

SECTION 1. *Policy.* The Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Federal agencies shall initiate measures needed to direct their policies, plans and programs so as to meet national environmental goals. The Council on Environmental Quality, through the Chairman, shall advise and assist the President in leading this national effort.

SEC. 2. *Responsibilities of Federal agencies.* Consonant with Title I of the National Environmental Policy Act of 1969, hereafter referred to as the "Act", the heads of Federal agencies shall:

(a) Monitor, evaluate, and control on a continuing basis their agencies' activities so as to protect and enhance the quality of the environment. Such activities shall include those directed to controlling pollution and enhancing the environment and those designed to accomplish other program objectives which may affect the quality of the environment. Agencies shall develop programs and measures to protect and enhance environmental quality and shall assess progress in meeting the specific objectives of such activities. Heads of agencies shall consult with appropriate Federal, State and local agencies in carrying out their activities as they affect the quality of the environment.

(b) Develop procedures to ensure the fullest practicable provision of timely public information and understanding of Federal plans and programs with environmental impact in order to obtain the views of interested parties. These procedures shall include, whenever appropriate, provision for public hearings, and shall provide the public with relevant information, including information on alternative courses of action. Federal agencies shall also encourage State and local agencies to adopt similar procedures for informing the public concerning their activities affecting the quality of the environment.

(c) Insure that information regarding existing or potential environmental problems and control methods developed as part of research, development, demonstration, test, or evaluation activities is made available to Federal agencies, States, counties, municipalities, institutions, and other entities, as appropriate.

(d) Review their agencies' statutory authority, administrative regulations, policies, and procedures, including those relating to loans, grants, contracts, leases, licenses, or permits, in order to identify any deficiencies or inconsistencies therein which prohibit or limit full compliance with the purposes and provisions of the Act. A report on this review and the corrective actions taken or planned, including such measures to be proposed to the President as may be necessary to bring their authority and policies into conformance with the intent, purposes, and procedures of the Act, shall be provided to the Council on Environmental Quality not later than September 1, 1970.

(e) Engage in exchange of data and research results, and cooperate with agencies of other governments to foster the purposes of the Act.

(f) Proceed, in coordination with other agencies, with actions required by section 102 of the Act.

SEC. 3. *Responsibilities of Council on Environmental Quality.* The Council on Environmental Quality shall:

(a) Evaluate existing and proposed policies and activities of the Federal Government directed to the control of pollution and the enhancement of the environment and to the accomplishment of other objectives which affect the quality of the environment. This shall include continuing review of procedures employed in the development and enforcement of Federal standards affecting environmental quality. Based upon such evaluations the Council shall, where appropriate, recommend to the President policies and programs to achieve more effective protection and enhancement of environmental quality and shall, where appropriate, seek resolution of significant environmental issues.

(b) Recommend to the President and to the agencies priorities among programs designed for the control of pollution and for enhancement of the environment.

(c) Determine the need for new policies and programs for dealing with environmental problems not being adequately addressed.

(d) Conduct, as it determines to be appropriate, public hearings or conferences on issues of environmental significance.

(e) Promote the development and use of indices and monitoring systems (1) to assess environmental conditions and trends, (2) to predict the environmental impact of proposed public and private actions, and (3) to determine the effectiveness of programs for protecting and enhancing environmental quality.

(f) Coordinate Federal programs related to environmental quality.

(g) Advise and assist the President and the agencies in achieving international cooperation for dealing with environmental problems, under the foreign policy guidance of the Secretary of State.

(h) Issue guidelines to Federal agencies for the preparation of detailed statements on proposals for legislation and other Federal actions affecting the environment, as required by section 102(2)(C) of the Act.

(i) Issue such other instructions to agencies, and request such reports and other information from them, as may be required to carry out the Council's responsibilities under the Act.

(j) Assist the President in preparing the annual Environmental Quality Report provided for in section 201 of the Act.

(k) Foster investigations, studies, surveys, research, and analyses relating to (i) ecological systems and environmental quality, (ii) the impact of new and changing technologies thereon, and (iii) means of preventing or reducing adverse effects from such technologies.

Sec. 4. *Amendments of E.O. 11472.* Executive Order No. 11472 of May 29, 1969, including the heading thereof, is hereby amended:

(1) By substituting for the term "the Environmental Quality Council", wherever it occurs, the following: "the Cabinet Committee on the Environment".

(2) By substituting for the term "the Council", wherever it occurs, the following: "the Cabinet Committee".

(3) By inserting in subsection (f) of section 101, after "Budget,", the following: "the Director of the Office of Science and Technology, ".

(4) By substituting for subsection (g) of section 101 the following:

"(g) The Chairman of the Council on Environmental Quality (established by Public Law 91-190) shall assist the President in directing the affairs of the Cabinet Committee."

(5) By deleting subsection (c) of section 102.

(6) By substituting for "the Office of Science and Technology", in section 104, the following: "the Council on Environmental Quality (established by Public Law 91-190)".

APPENDIX D-7

TABULAR SUMMARY OF POTASH LEASES IN ORDER OF LEASE READJUSTMENT DATE

Serial Number	Map Number	*Lease Date	Lessee	Number of Acres	Date of Next Lease Readjustment	Primary Township and Range
NM 07005	39	1/02/52	***Mississippi Potash, Inc.	1,276.28	1/02/72	T. 20 S., R. 31 E.
NM 011776	47	1/09/52	National Potash Co.	2,559.06	1/09/72	T. 20 S., R. 32 E.
NM 011777	51	1/09/52	National Potash Co.	1,117.64	1/09/72	T. 20 S., R. 32 E.
LC 065275	38	1/09/52	National Potash Co.	2,550.56	1/09/72	T. 20 S., R. 31 E.
LC 065286	48	1/09/52	National Potash Co.	2,553.87	1/09/72	T. 20 S., R. 32 E.
LC 068397	49	1/09/52	National Potash Co.	1,920.00	1/09/72	T. 20 S., R. 32 E.
LC 043638-A	43	8/07/52	**Mississippi Potash, Inc.	1,524.03	8/07/72	T. 20 S., R. 30 E. & T. 20 S., R. 31 E. & T. 21 S., R. 29 E. & T. 21 S., R. 30 E.
LC 043636-B	42	8/07/52	**Mississippi Potash, Inc.	2,311.66	8/07/72	T. 20 S., R. 31 E. & T. 21 S., R. 30 E.
LC 043636-C	66	8/07/52	**Mississippi Potash, Inc.	920.00	8/07/72	T. 21 S., R. 29 E. & T. 21 S., R. 30 E.
NM 1225	37	8/07/52	Duval Corp.	480.00	8/07/72	T. 20 S., R. 30 E.
LC 048730-A	94	8/21/52	Duval Corp.	2,560.00	8/21/72	T. 22 S., R. 30 E.
LC 048730-B	95	8/21/52	Duval Corp.	2,440.00	8/21/72	T. 22 S., R. 30 E. & T. 23 S., R. 30 E.
NM 18417	57	11/09/52	Kerr-McGee Corp.	160.00	11/09/72	T. 20 S., R. 32 E.
NM 016330-A	1	11/18/52	Duval Corp.	1,760.00	11/18/72	T. 18 S., R. 30 E.
NM 016330-B	2	11/18/52	Duval Corp.	1,240.00	11/18/72	T. 18 S., R. 30 E.
LC 046729-A	9	1/18/33	Ideal Basic Industries, Inc.	2,558.76	1/18/73	T. 19 S., R. 30 E. & T. 20 S., R. 30 E.
LC 046729-C	10	1/18/33	Ideal Basic Industries, Inc.	2,279.95	1/18/73	T. 19 S., R. 30 E. & T. 20 S., R. 30 E.
LC 046729-D	11	1/18/33	Ideal Basic Industries, Inc.	1,840.00	1/18/73	T. 19 S., R. 30 E. & T. 20 S., R. 30 E.

*(Case Type)

TABULAR SUMMARY OF POTASH LEASES - CONT'D. PAGE

Serial Number	Map Number	*Lease Date	Lessee	Number of Acres	Date of Next Lease Readjustment	Primary Township and Range
LC 065411	33	2/12/53	Ideal Basic Industries, Inc.	160.00	2/12/73	T. 20 S., R. 30 E.
NM 01329-A	58	2/24/53	****Harroun & Haworth	2,564.33	2/24/73	T. 20 S., R. 33 E.
NM 013298-B	46	2/24/53	****Harroun & Haworth	2,078.80	2/24/73	T. 20 S., R. 32 E.
NM 013298-C	50	2/24/53	Harroun & Haworth	2,360.00	2/24/73	T. 20 S., R. 32 E.
NM 013299	12	2/24/53	****Harroun & Haworth	1,277.80	2/24/73	T. 19 S., R. 32 E. & T. 19 S., R. 33 E.
NM 0554862	54	2/24/53	Kerr-McGee Corp.	480.00	2/24/73	T. 20 S., R. 32 E.
NM 0554863	53	2/24/53	Kerr-McGee Corp.	200.00	2/24/73	T. 20 S., R. 32 E.
NM 0554864	56	2/24/53	Kerr-McGee Corp.	1,250.04	2/24/73	T. 21 S., R. 31 E. & T. 20 S., R. 32 E.
NM 0554863	53	2/24/53	Kerr-McGee Corp.	200.00	2/24/73	T. 20 S., R. 32 E.
NM 06859	79	10/26/53	Kerr-McGee Corp.	2,554.24	10/26/73	T. 21 S., R. 31 E.
NM 015064-A	52	10/26/53	Kerr-McGee Corp	1,599.76	10/26/73	T. 20 S., R. 32 E.
NM 015064-B	55	10/26/53	Kerr-McGee Corp.	1,280.00	10/26/73	T. 20 S., R. 32 E.
NM 015064-C	77	10/26/53	Kerr-McGee Corp.	1,049.40	10/26/73	T. 21 S., R. 31 E.
LC 065484	68	1/07/54	Duval Corp.	1,011.76	1/07/74	T. 21 S., R. 29 E. & T. 21 S., R. 30 E.
NM 10926	27	1/1/55	Ideal Basic Industries, Inc.	360.00	1/1/75	T. 20 S., R. 30 E.
NM 0184149	28	1/01/55	**Mississippi Potash, Inc.	80.00	1/01/75	T. 20 S., R. 30 E.
LC 066026	25	9/01/55	Ideal Basic Industries,Inc.	200.00	9/01/75	T. 20 S., R. 30 E.
LC 071868	76	9/01/55	Kerr-McGee Corp.	1,938.24	9/01/75	T. 21 S., R. 31 E.
LC 044752	19	9/01/56	National Potash Co.	240.00	9/01/76	T. 20 S., R. 29 E.
NM 02160	97	11/01/56	Intern'l. Minerals Chemical Corp.	638.78	11/01/76	T. 23 S., R. 29 E.
NM 07755	74	6/01/57	Duval Corp.	665.65	6/01/77	T. 21 S., R. 30 E.
NM 029244	59	7/01/57	Harroun & Haworth	2,560.00	7/01/77	T. 20 S., R. 33 E.
NM 029245	61	7/01/57	Harroun & Haworth	2,560.68	7/01/77	T. 20 S., R. 33 E. & T. 20 S., R. 34 E.
NM 029246	60	7/01/57	Harroun & Haworth	2,560.83	7/01/77	T. 20 S., R. 33 E. & T. 20 S., R. 34 E.

* (Case Type)

TABULAR SUMMARY OF POTASH LEASES - CONT'D. PAGE

Serial Number	Map Number	*Lease Date	Lessee	Number of Acres	Date of Next Lease Readjustment	Primary Township and Range
NM 036791	18	10/01/57	National Potash Co.	1,840.00	10/01/77	T. 20 S., R. 29 E.
NM 035383	81	1/01/58	Kerr-McGee Corp.	2,400.00	1/01/78	T. 21 S., R. 31 E.
NM 06101	41	2/01/58	**Mississippi Potash, Inc.	1,040.00	2/01/78	T. 20 S., R. 31 E.
LC 065693	45	2/01/58	**Mississippi Potash, Inc.	560.00	2/01/78	T. 20 S., R. 31 E.
NM 033696	40	3/01/58	Kerr-McGee Corp.	960.00	3/01/78	T. 20 S., R. 31 E.
NM 033696-A	78	3/01/58	Kerr-McGee Corp.	1,240.62	3/01/78	T. 21 S., R. 31 E.
NM 045326	84	5/01/58	Intern'l. Minerals & Chemical Corp.	640.00	5/01/78	T. 22 S., R. 29 E.
NM 029243	62	6/01/58	Harroun & Haworth	2,560.00	6/01/78	T. 20 S., R. 34 E.
NM 045410	80	6/01/58	Kerr-McGee Corp.	1,916.24	6/01/78	T. 21 S., R. 31 E.
NM 03468	71	7/01/58	Kerr-McGee Corp.	160.00	7/01/78	T. 21 S., R. 30 E.
LC 044311-A	75	10/26/38	Intern'l. Minerals & Chemical Corp.	2,550.33	10/26/78	T. 22 S., R. 29 E.
LC 044311-B	86	10/26/38	Intern'l. Minerals & Chemical Corp.	2,560.00	10/26/78	T. 22 S., R. 29 E.
LC 044311-C	87	10/26/38	Intern'l. Minerals & Chemical Corp.	2,563.20	10/26/78	T. 22 S., R. 30 E.
LC 070141	24	1/01/59	Ideal Basic Industries, Inc.	438.91	1/01/79	T. 20 S., R. 30 E.
LC 050063-B	31	4/15/39	Ideal Basic Industries, Inc.	2,560.00	4/15/79	T. 20 S., R. 30 E.
LC 050063-F	21	4/15/39	Ideal Basic Industries, Inc.	2,358.36	4/15/79	T. 20 S., R. 29 E. & T. 20 S., R. 30 E.
NM 063880	63	7/01/59	**Mississippi Potash, Inc.	120.00	7/01/79	T. 21 S., R. 29 E.
LC 062188	92	12/01/59	Duval Corp.	2,360.00	12/01/79	T. 22 S., R. 30 E.
NM 070607	70	2/01/60	**Mississippi Potash, Inc.	551.70	2/01/80	T. 21 S., R. 30 E.
NM 016540	72	4/01/60	**Mississippi Potash, Inc.	120.00	4/01/80	T. 21 S., R. 30 E.
NM 088285	26	8/01/60	Ideal Basic Industries, Inc	120.00	8/01/80	T. 20 S., R. 30 E.
NM 0135065	7	6/01/61	Ideal Basic Industries, Inc.	200.00	6/01/81	T. 19 S., R. 30 E.
NM 0220116	6	12/01/61	Ideal Basic Industries, Inc.	800.00	12/01/81	T. 19 S., R. 30 E.
NM 023623	17	2/02/62	Ideal Basic Industries, Inc.	400.00	2/02/82	T. 20 S., R. 29 E.
NM 014742	73	8/01/63	Kerr-McGee Corp.	1,400.00	8/01/83	T. 21 S., R. 30 E.
NM 050249-A	14	9/01/63	Ideal Basic Industries, Inc.	880.00	9/01/83	T. 20 S., R. 29 E.
NM 050249-B	15	10/01/63	Ideal Basic Industries, Inc.	240.00	10/01/83	T. 20 S., R. 29 E.
NM 057287	83	1/01/64	Kerr-McGee Corp.	1,280.00	1/01/84	T. 21 S., R. 31 E.

*(Case Type)

APPENDIX D-7 cont.

TABULAR SUMMARY OF POTASH LEASES - CONT'D. PAGE

Serial Number	Map Number	*Lease Date	Lessee	Number of Acres	Date of Next Lease Readjustment	Primary Township and Range
NM 0121810	13	1/01/65	Ideal Basic Industries, Inc.	640.00	1/01/85	T. 20 S., R. 29 E.
NM 0146970	23	6/01/65	Ideal Basic Industries, Inc.	239.06	6/01/85	T. 20 S., R. 30 E.
LC 044312-A	69	11/15/46	Intern'l. Minerals & Chemical Corp.	382.37	11/15/86	T. 21 S., R. 29 E. & T. 21 S., R. 30 E.
LC 044312-B	88	11/15/46	Intern'l. Minerals & Chemical Corp.	40.00	11/15/86	T. 22 S., R. 29 E.
LC 044312-C	89	11/15/46	Intern'l. Minerals & Chemical Corp.	1,159.98	11/15/86	T. 22 S., R. 29 E. & T. 22 S., R. 30 E.
NM 0292684	82	12/01/66	Kerr-McGee Corp.	1,920.00	12/01/86	T. 21 S., R. 31 E.
NM 0329206	112	3/01/67	Day Mines, Inc.	1,920.00	3/01/87	T. 23 S., R. 31 E.
NM 0329207	113	3/01/67	Day Mines, Inc.	2,560.00	3/01/87	T. 23 S., R. 31 E.
NM 0329208	114	3/01/67	Day Mines, Inc.	1,287.00	3/01/87	T. 23 S., R. 31 E.
NM 0329209	115	3/01/67	Day Mines, Inc.	2,560.00	3/01/87	T. 23 S., R. 31 E.
NM 0329210	116	3/01/67	Day Mines, Inc.	2,560.00	3/01/87	T. 23 S., R. 31 E.
NM 0329205	111	3/01/67	Day Mines, Inc.	2,566.40	3/01/87	T. 23 S., R. 31 E.
NM 0349889	101	11/01/67	Leland A. Hodges, Trustee	2,520.00	11/01/87	T. 23 S., R. 29 E.
NM 0349891	108	11/01/67	Leland A. Hodges, Trustee	2,560.84	11/01/87	T. 23 S., R. 30 E.
NM 0349892	109	11/01/67	Leland A. Hodges, Trustee	1,080.00	11/01/87	T. 23 S., R. 30 E.
NM 0359157	105	11/01/67	Intern'l. Minerals & Chemical Corp.	960.20	11/01/87	T. 23 S., R. 30 E.
NM 0359158	106	11/01/67	Intern'l. Minerals & Chemical Corp.	2,520.00	11/01/87	T. 23 S., R. 30 E.
NM 0359160	103	11/01/67	Intern'l. Minerals & Chemical Corp.	320.96	11/01/87	T. 23 S., R. 30 E.
NM 0384584	96	11/01/67	Intern'l. Minerals & Chemical Corp.	2,557.69	11/01/87	T. 22 S., R. 31 E. & T. 23 S., R. 31 E.
NM 0384585	102	11/01/67	Leland A. Hodges, Trustee	1,280.00	11/01/87	T. 23 S., R. 29 E.
NM 6829	104	11/01/67	Intern'l. Minerals & Chemical Corp.	2,211.12	11/01/87	T. 23 S., R. 30 E. & T. 23 S., R. 31 E.
NM 6830	110	11/01/67	Intern'l. Minerals & Chemical Corp.	960.00	11/01/87	T. 23 S., R. 30 E.
NM 0359159	107	2/01/68	Intern'l. Minerals & Chemical Corp.	1,320.00	2/01/88	T. 23 S., R. 30 E.
NM 10543	90	11/01/69	Leland A. Hodges, Trustee	800.00	11/01/89	T. 22 S., R. 29 E.
NM 10544	98	11/01/69	Leland A. Hodges, Trustee	2,084.45	11/01/89	T. 23 S., R. 29 E.
NM 10545	99	11/01/69	Leland A. Hodges, Trustee	2,560.00	11/01/89	T. 23 S., R. 29 E.
NM 10546	100	11/01/69	Leland A. Hodges, Trustee	2,560.00	11/01/89	T. 23 S., R. 29 E.
LC 065209	85	11/01/69	Intern'l. Minerals & Chemical Corp.	2,000.00	11/01/89	T. 22 S., R. 29 E.

*(Case Type)

TABULAR SUMMARY OF POTASH LEASES - CONT'D. PAGE

Serial Number	Map Number	*Lease Date	Lessee	Number of Acres	Date of Next Lease Readjustment	Primary Township and Range
LC 036092-A	64	11/21/69	**Mississippi Potash, Inc.	2,436.85	11/21/89	T. 21 S., R. 29 E. & T. 21 S., R. 30 E.
LC 036092-B	67	11/21/69	**Mississippi Potash, Inc.	2,025.59	11/21/89	T. 21 S., R. 29 E. & T. 21 S., R. 30 E.
LC 036092-C	44	11/21/69	**Mississippi Potash, Inc.	2,559.15	11/21/89	T. 21 S., R. 30 E. & T. 20 S., R. 31 E.
NM 0184150	29	11/30/69	***Mississippi Potash,Inc.	320.00	11/30/89	T. 20 S., R. 30 E.
LC 063241-A	34	11/30/69	Duval Corp.	2,560.00	11/30/89	T. 20 S., R. 30 E.
LC 063241-B	20	11/30/69	Duval Corp.	720.00	11/30/89	T. 20 S., R. 29 E. & T. 20 S., R. 30 E.
LC 063241-C	22	11/30/69	Duval Corp.	1,262.95	11/30/89	T. 20 S., R. 30 E. & T. 20 S., R. 31 E.
LC 067319-A	3	9/11/70	Amax Chemical Corp.	2,557.68	9/11/90	T. 19 S., R. 30 E.
LC 067319-B	4	9/11/70	Amax Chemical Corp.	2,560.00	9/11/90	T. 19 S., R. 30 E.
LC 067319-C	5	9/11/70	Amax Chemical Corp.	2,560.00	9/11/90	T. 19 S., R. 30 E.
LC 065081	32	12/06/70	Ideal Basic Industries, Inc.	480.00	12/06/90	T. 20 S., R. 30 E.
NM 12763	35	6/01/71	Ideal Basic Industries, Inc.	160.00	6/01/91	T. 20 S., R. 30 E.
NM 09118-C	91	7/02/71	Intern'l. Minerals Chemical Corp.	1,400.60	7/02/91	T. 22 S., R. 29 E. & T. 23 S., R. 30 E.
NM 09118-A	93	7/02/71	Intern'l. Minerals Chemical Corp.	1,766.71	7/02/91	T. 22 S., R. 30 E. & T. 23 S., R. 30 E.
NM 1226	36	7/06/71	Duval Corp.	480.00	7/06/91	T. 20 S., R. 30 E.
LC 061847	30	7/06/71	**Mississippi Potash, Inc.	1,755.24	7/06/91	T. 20 S., R. 30 E. & T. 20 S., R. 31 E.
LC 065566	8	9/28/71	Ideal Basic Industries, Inc.	720.00	9/28/91	T. 19 S., R. 30 E.
NM 13933	16	10/01/71	Ideal Basic Industries, Inc.	80.00	10/01/91	T. 20 S., R. 29 E.
NM 13932	117	11/01/74	Kerr-McGee Corp.	640.00	11/01/94	T. 20 S., R. 31 E.

**Assignment pending to Mississippi Chemical Corporation.

***Two assignments pending to Mississippi Chemical Corporation & Duval Corporation.

****Assignment pending to Noranda Exploration.

*(Case Type)

APPENDIX D-8

TABULAR SUMMARY OF ALL POTASH APPLNS.

As of June 25, 1975

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 15406	2-1-72	Daniel S. Harroun	2,480.00	T. 20 S., R. 33 E.
NM 15407	2-1-72	Daniel S. Harroun	2,562.05	T. 23 S., R. 31 E.
NM 18090	2-15-73	Leland A. Hodges, Trustee	2,520.00	T. 23 S., R. 30 E.
NM 18715	6-1-73	Daniel S. Harroun	2,520.00	T. 20 S., R. 33 E.
NM 18716	6-1-73	Daniel S. Harroun	2,440.52	T. 19 S., R. 33 E.& T. 20 S., R. 33 E.
NM 18717	6-1-73	Daniel S. Harroun	680.00	T. 19 S., R. 33 E.& T. 20 S., R. 33 E.
NM 21658	4-29-74	Amax Chemical Corp.	1,880.00	T. 19 S., R. 30 E.
NM 21659	4-29-74	Amax Chemical Corp.	880.00	T. 19 S., R. 30 E.
NM 21660	4-29-74	Amax Chemical Corp.	1,880.00	T. 18 S., R. 30 E.& T. 19 S., R. 30 E.
NM 21661	4-29-74	Amax Chemical Corp.	2,560.00	T. 18 S., R. 30 E.& T. 19 S., R. 30 E.
NM 21662	4-29-74	Amax Chemical Corp.	2,560.00	T. 18 S., R. 30 E.& T. 19 S., R. 30 E.
NM 21682	5-2-74	R. J. Zonne	2,544.28	T. 22 S., R. 32 E.
NM 21837	5-15-74	Noranda Exploration, Inc.	2,520.00	T. 19 S., R. 33 E.
NM 21838	5-15-74	Noranda Exploration, Inc.	1,360.00	T. 20 S., R. 33 E.
NM 21839	5-15-74	Noranda Exploration, Inc.	1,920.00	T. 20 S., R. 33 E.
NM 21840	5-15-74	Noranda Exploration, Inc.	2,518.36	T. 19 S., R. 33 E.& T. 20 S., R. 33 E.
NM 21958	5-28-74	Day Mines, Inc.	2,040.00	T. 23 S., R. 31 E.& T. 24 S., R. 31 E.

*(Case type)

SUMMARY OF ALL POTASH APPLS.CONT'D. - PAGE 2

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 23588	10-2-74	Leland A. Hodges, Trustee	2,559.91	T. 23 S., R. 30 E.& T. 24 S., R. 30 E.
NM 23589	10-2-74	Leland A. Hodges, Trustee	2,576.96	T. 24 S., R. 31 E.
NM 23590	10-2-74	Leland A. Hodges, Trustee	2,545.16	T. 24 S., R. 31 E.
NM 23591	10-2-74	Leland A. Hodges, Trustee	2,560.00	T. 24 S., R. 30 E.
NM 23592	10-2-74	Leland A. Hodges, Trustee	2,439.95	T. 24 S., R. 30 E.& T. 24 S., R. 31 E.
NM 23616	10-7-74	Mark L. Robinson	2,559.86	T. 24 S., R. 30 E.
NM 23627	10-10-74	Noranda Exploration, Inc.	2,480.00	T. 22 S., R. 31 E.
NM 23628	10-10-74	Noranda Exploration, Inc.	2,492.52	T. 21 S., R. 32 E.
NM 23629	10-10-74	Noranda Exploration, Inc.	2,520.45	T. 21 S., R. 32 E.& T. 22 S., R. 32 E.
NM 23630	10-10-74	Noranda Exploration, Inc.	1,999.71	T. 21 S., R. 32 E.& T. 22 S., R. 32 E.
NM 23631	10-10-74	Noranda Exploration, Inc.	1,952.55	T. 22 S., R. 32 E.
NM 23632	10-10-74	Noranda Exploration, Inc.	2,559.24	T. 22 S., R. 31 E.
NM 23633	10-10-74	Noranda Exploration, Inc.	2,560.00	T. 22 S., R. 31 E.
NM 23634	10-10-74	Noranda Exploration, Inc.	2,518.18	T. 21 S., R. 31 E.& T. 22 S., R. 31 E.
NM 23635	10-10-74	Noranda Exploration, Inc.	2,557.26	T. 22 S., R. 32 E.
NM 23636	10-10-74	Noranda Exploration, Inc.	2,526.38	T. 21 S., R. 32 E.
NM 23637	10-10-74	Noranda Exploration, Inc.	2,555.84	T. 21 S., R. 32 E.
NM 23638	10-10-74	Noranda Exploration, Inc.	2,475.20	T. 21 S., R. 32 E.
NM 23639	10-10-74	Noranda Exploration, Inc.	2,560.00	T. 21 S., R. 32 E.
NM 23665	10-24-74	Mark L. Robinson	2,522.00	T. 24 S., R. 30 E.& T. 24 S., R. 29 E.
NM 23706	11-4-74	Day Mines, Inc.	1,920.00	T. 23 S., R. 32 E.
NM 23707	11-4-74	Day Mines, Inc.	2,560.00	T. 23 S., R. 32 E.
NM 23708	11-4-74	Day Mines, Inc.	1,920.00	T. 23 S., R. 32 E.
NM 23709	11-4-74	Day Mines, Inc.	1,280.00	T. 23 S., R. 32 E.
NM 23710	11-4-74	Day Mines, Inc.	2,560.00	T. 23 S., R. 32 E.
NM 24223	12-18-74	Day Mines, Inc.	1,600.11	T. 23 S., R. 31 E.& T. 24 S., R. 31 E.
NM 24224	12-18-74	Day Mines, Inc.	1,920.00	T. 24 S., R. 31 E.
NM 24225	12-18-74	Day Mines, Inc.	1,920.00	T. 24 S., R. 31 E.

*(Case Type)

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 3

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 24257	12-27-74	Day Mines, Inc.	1,663.05	T. 23 S., R. 32 E.
NM 24258	12-27-74	Day Mines, Inc.	1,635.99	T. 23 S., R. 31 E.& T. 23 S., R. 32 E.
NM 24513	1-14-75	Leland A. Hodges, Trustee	2,548.56	T. 24 S., R. 31 E.& T. 25 S., R. 31 E.
NM 24514	1-14-75	Leland A. Hodges, Trustee	2,474.36	T. 24 S., R. 31 E.& T. 25 S., R. 31 E.
NM 24578	1-24-75	Amax Chemical Corp.	2,560.00	T. 19 S., R. 33 E.
NM 24579	1-24-75	Amax Chemical Corp.	2,560.00	T. 19 S., R. 33 E.
NM 24580	1-24-75	Amax Chemical Corp.	1,920.00	T. 19 S., R. 33 E.
NM 24581	1-24-75	Amax Chemical Corp.	2,080.00	T. 19 S., R. 33 E.& T. 20 S., R. 33 E.
NM 24582	1-24-75	Amax Chemical Corp.	2,400.00	T. 19 S., R. 33 E.
NM 24583	1-24-75	Amax Chemical Corp.	2,560.00	T. 20 S., R. 33 E.
NM 24584	1-24-75	Amax Chemical Corp.	2,560.00	T. 19 S., R. 31 E.
NM 24585	1-24-75	Amax Chemical Corp.	2,400.00	T. 20 S., R. 33 E.
NM 24586	1-24-75	Amax Chemical Corp.	2,560.00	T. 21 S., R. 32 E.
NM 24587	1-24-75	Amax Chemical Corp.	2,520.00	T. 21 S., R. 32 E.
NM 24588	1-24-75	Amax Chemical Corp.	2,440.00	T. 21 S., R. 32 E.
NM 24589	1-24-75	Amax Chemical Corp.	2,400.00	T. 21 S., R. 32 E.
NM 24590	1-24-75	Amax Chemical Corp.	2,208.54	T. 21 S., R. 32 E.
NM 24591	1-24-75	Amax Chemical Corp.	2,520.00	T. 23 S., R. 30 E.
NM 24592	1-24-75	Amax Chemical Corp.	2,520.00	T. 23 S., R. 30 E.& T. 24 S., R. 30 E.
NM 24593	1-24-75	Amax Chemical Corp.	2,520.00	T. 24 S., R. 30 E.
NM 24594	1-24-75	Amax Chemical Corp.	2,520.00	T. 24 S., R. 30 E.
NM 24625	2-3-75	Emmet E. Wolter	800.00	T. 18 S., R. 31 E.
NM 24785	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,561.20	T. 20 S., R. 29 E.
NM 24786	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 20 S., R. 29 E.
NM 24787	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 21 S., R. 29 E.
NM 24788	2-24-75	Gilbert E. Fowler and Christian F. Murer	966.00	T. 22 S., R. 29 E.
NM 24789	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,408.04	T. 22 S., R. 29 E.

*(Case Type)

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 4

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 24790	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,361.68	T. 22 S., R. 29 E.
NM 24791	2-24-75	Gilbert E. Fowler and Christian F. Murer	1,520.00	T. 23 S., R. 29 E.
NM 24792	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 24 S., R. 29 E.
NM 24793	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,440.00	T. 24 S., R. 29 E.
NM 24794	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 24 S., R. 29 E.
NM 24795	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,540.00	T. 24 S., R. 29 E.
NM 24796	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 29 E.
NM 24797	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 29 E.
NM 24798	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 29 E.
NM 24799	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 29 E.
NM 24800	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 26 S., R. 29 E.
NM 24801	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.64	T. 18 S., R. 30 E.
NM 24802	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,553.44	T. 18 S., R. 30 E.
NM 24803	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,514.00	T. 18 S., R. 30 E.
NM 24804	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,076.48	T. 18 S., R. 30 E.
NM 24805	2-24-75	Gilbert E. Fowler and Christian F. Murer	680.00	T. 19 S., R. 30 E.
NM 24806	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 24 S., R. 30 E.
NM 24807	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 24 S., R. 30 E.
NM 24808	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 24 S., R. 30 E.
NM 24809	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.

*(Case Type)

APPENDIX D-8 cont.

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 5

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 24810	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.
NM 24811	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.
NM 24812	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.
NM 24813	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.
NM 24814	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.
NM 24815	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 30 E.
NM 24816	2-24-75	Gilbert E. Fowler and Christian F. Murer	1,880.00	T. 20 S., R. 31 E.
NM 24817	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 22 S., R. 31 E.
NM 24818	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24819	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24820	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24821	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24822	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24823	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24824	2-24-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 25 S., R. 31 E.
NM 24897	3-3-75	Gilbert E. Fowler Christian F. Murer	1,280.00	T. 24 S., R. 31 E.
NM 24898	3-3-75	Gilbert E. Fowler and Christian F. Murer	640.00	T. 22 S., R. 29 E.
NM 24899	3-3-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 22 S., R. 31 E.
NM 24900	3-3-75	Gilbert E. Fowler and Christian F. Murer	2,560.00	T. 22 S., R. 31 E.

*(Case Type)

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 6

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 24905	3-4-75	Karla R. Aden	2,520.00	T. 19 S., R. 31 E.
NM 24906	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24907	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24908	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24909	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24910	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24911	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24912	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 31 E.
NM 24913	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24914	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24915	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24916	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24917	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24918	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24919	3-4-75	Karla R. Aden	2,560.00	T. 19 S., R. 32 E.
NM 24920	3-4-75	Karla R. Aden	1,640.00	T. 19 S., R. 32 E.
NM 24921	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 31 E.
NM 24922	3-4-75	Michael J. Hennessy	2,400.00	T. 18 S., R. 31 E.
NM 24923	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 31 E.
NM 24924	3-4-75	Michael J, Hennessy	2,560.00	T. 18 S., R. 31 E.
NM 24925	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 31 E.
NM 24926	3-4-75	Michael J. Hennessy	2,400.00	T. 18 S., R. 31 E.
NM 24927	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 31 E.
NM 24928	3-4-75	Michael J. Hennessy	1,920.00	T. 18 S., R. 31 E.
NM 24929	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 24930	3-4-75	Michael J. Hennessy	2,240.00	T. 18 S., R. 32 E.
NM 24931	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 24932	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 24933	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 24934	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 24935	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 24936	3-4-75	Michael J. Hennessy	2,560.00	T. 18 S., R. 32 E.
NM 25034	3-12-75	Dale A. Whittenburg	2,400.00	T. 18 S., R. 30 E.
NM 25119	3-19-75	Dale A. Whittenburg	2,560.00	T. 26 S., R. 30 E.
NM 25120	3-19-75	Dale A. Whittenburg	2,560.00	T. 26 S., R. 30 E.
NM 25121	3-19-75	Dale A. Whittenburg	2,560.00	T. 26 S., R. 30 E.
NM 25133	3-20-75	Lemon Saks	2,560.00	T. 26 S., R. 30 E.
NM 25134	3-20-75	Lemon Saks	2,560.00	T. 26 S., R. 30 E.

***(Case Type)**

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 7

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 25135	3-20-75	Lemon Saks	1,035.32	T. 26 S., R. 30 E.
NM 25136	3-20-75	Lemon Saks	2,320.00	T. 26 S., R. 31 E.
NM 25137	3-20-75	Lemon Saks	2,440.00	T. 26 S., R. 31 E.
NM 25138	3-20-75	Lemon Saks	2,520.00	T. 26 S., R. 31 E.
NM 25139	3-20-75	Lemon Saks	2,560.00	T. 26 S., R. 31 E.
NM 25140	3-20-75	Lemon Saks	2,560.00	T. 26 S., R. 30 E.
NM 25141	3-20-75	Lemon Saks	2,560.00	T. 26 S., R. 30 E.
NM 25142	3-20-75	Lemon Saks	2,560.00	T. 26 S., R. 29 E.
NM 25144	3-21-75	Charles A. Denton	2,560.00	T. 18 S., R. 33 E.
NM 25145	3-21-75	Charles A. Denton	1,920.00	T. 18 S., R. 33 E.
NM 25146	3-21-75	Charles A. Denton	2,560.00	T. 23 S., R. 32 E.
NM 25147	3-21-75	Charles A. Denton	2,560.00	T. 23 S., R. 32 E.
NM 25148	3-21-75	Charles A. Denton	2,560.00	T. 23 S., R. 32 E.
NM 25149	3-21-75	Charles A. Denton	2,560.00	T. 23 S., R. 32 E.
NM 25150	3-21-75	Charles A. Denton	2,560.00	T. 22 S., R. 32 E.
NM 25151	3-21-75	Charles A. Denton	2,560.00	T. 22 S., R. 32 E.
NM 25152	3-21-75	Charles A. Denton	2,560.00	T. 22 S., R. 32 E.
NM 25153	3-21-75	Charles A. Denton	2,560.00	T. 22 S., R. 32 E.
NM 25154	3-21-75	Charles A. Denton	2,560.00	T. 22 S., R. 32 E.
NM 25155	3-21-75	Charles A. Denton	1,920.00	T. 22 S., R. 32 E.
NM 25156	3-21-75	Charles A. Denton	1,280.00	T. 25 S., R. 31 E.
NM 25157	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25158	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25159	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25160	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25161	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25162	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25163	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25164	3-21-75	Charles A. Denton	2,560.00	T. 24 S., R. 32 E.
NM 25168	3-24-75	Harvey E. Yates, Jr.	2,560.00	T. 20 S., R. 28 E.& T. 20 S., R. 29 E.
NM 25174	3-27-75	Ann Denton	2,560.00	T. 18 S., R. 33 E.
NM 25175	3-27-75	Ann Denton	2,440.00	T. 18 S., R. 33 E.
NM 25176	3-27-75	Ann Denton	2,560.00	T. 18 S., R. 33 E.
NM 25177	3-27-75	Ann Denton	2,240.00	T. 18 S., R. 33 E.
NM 25178	3-27-75	Ann Denton	2,560.00	T. 18 S., R. 33 E.
NM 25179	3-27-75	Ann Denton	2,560.00	T. 20 S., R. 34 E.

*(Case Type)

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 8

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 25180	3-27-75	Ann Denton	2,560.00	T. 20 S., R. 34 E.
NM 25181	3-27-75	Ann Denton	2,560.00	T. 20 S., R. 34 E.
NM 25182	3-27-75	Ann Denton	2,560.00	T. 20 S., R. 34 E.
NM 25183	3-27-75	Ann Denton	800.00	T. 19 S., R. 34 E.
NM 25184	3-27-75	Ann Denton	2,560.00	T. 19 S., R. 34 E.
NM 25185	3-27-75	Ann Denton	2,560.00	T. 19 S., R. 34 E.
NM 25186	3-27-75	Ann Denton	2,560.00	T. 19 S., R. 34 E.
NM 25187	3-27-75	Ann Denton	2,560.00	T. 19 S., R. 34 E.
NM 25188	3-27-75	Ann Denton	2,560.00	T. 19 S., R. 34 E.
NM 25189	3-27-75	Ann Denton	2,560.00	T. 19 S., R. 34 E.
NM 25190	3-27-75	Ann Denton	2,560.00	T. 22 S., R. 33 E.
NM 25191	3-27-75	Ann Denton	2,200.00	T. 22 S., R. 33 E.
NM 25192	3-27-75	Ann Denton	2,560.00	T. 22 S., R. 33 E.
NM 25193	3-27-75	Ann Denton	2,560.00	T. 22 S., R. 33 E.
NM 25194	3-27-75	Ann Denton	2,560.00	T. 22 S., R. 33 E.
NM 25195	3-28-75	T. L. Archer	2,280.00	T. 22 S., R. 33 E.
NM 25196	3-28-75	T. L. Archer	2,560.00	T. 19 S., R. 33 E.
NM 25197	3-28-75	T.L. Archer	2,560.00	T. 19 S., R. 33 E.
NM 25198	3-28-75	T. L. Archer	960.00	T. 20 S., R. 35 E.
NM 25199	3-28-75	T. L. Archer	2,560.00	T. 20 S., R. 35 E.
NM 25200	3-28-75	T. L. Archer	2,560.00	T. 20 S., R. 35 E.
NM 25201	3-28-75	T. L. Archer	2,560.00	T. 20 S., R. 35 E.
NM 25202	3-28-75	T. L. Archer	1,280.00	T. 22 S., R. 34 E.
NM 25203	3-28-75	T. L. Archer	2,560.00	T. 22 S., R. 34 E.
NM 25204	3-28-75	T. L. Archer	2,560.00	T. 22 S., R. 34 E.
NM 25205	3-28-75	T. L. Archer	2,560.00	T. 22 S., R. 34 E.
NM 25206	3-28-75	T. L. Archer	2,560.00	T. 22 S., R. 34 E.
NM 25207	3-28-75	T. L. Archer	2,560.00	T. 22 S., R. 34 E.
NM 25230	3-31-75	T. L. Archer	960.00	T. 21 S., R. 33 E. &
NM 25265	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 21 S., R. 33 E. & T. 22 S., R. 33 E.
NM 25266	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 22 S., R. 33 E.
NM 25267	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 22 S., R. 33 E. & T. 22 S., R. 34 E.
NM 25268	4-9-75	Ideal Basic Industries, Inc.	1,920.00	T. 21 S., R. 34 E.
NM 25269	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 22 S., R. 34 E.

*(Case Type)

SUMMARY OF ALL POTASH APPLS. CONT'D. - PAGE 9

Serial Number	*Prospecting Permit Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 25270	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 21 S., R. 32 E.
NM 25271	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 21 S., R. 32 E.
NM 25272	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 21 S., R. 32 E.
NM 25273	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 21 S., R. 32 E.
NM 25274	4-9-75	Ideal Basic Industries, Inc.	2,560.00	T. 21 S., R. 32 E.
NM 25397	4-15-75	Harvey E. Yates, Jr.	2,560.00	T. 20 S., R. 29 E.
NM 25398	4-15-75	Harvey E. Yates, Jr.	1,920.00	T. 20 S., R. 28 E.
226 Total Appls.			**533,573.79 Total Acres**	

SUMMARY OF ALL POTASH APPLS. CONT'D. PAGE-10

Serial Number	Competitive Applns. Filed	Applicant's Name	Number of Acres	Primary Township and Range
NM 21604	4-22-74	Amax Chemical Corp.	120.00	T. 19 S., R. 30 E.
NM 21605	4-22-74	Amax Chemical Corp.	760.00	T. 19 S., R. 30 E.
NM 21606	4-22-74	Amax Chemical Corp.	440.00	T. 19 S., R. 30 E.
NM 21607	4-22-74	Amax Chemical Corp.	320.00	T. 19 S., R. 30 E.
NM 22001	6-5-74	Amax Chemical Corp.	1,640.00	T. 19 S., R. 30 E.
NM 22425	6-19-74	Kerr-McGee Corp.	2,240.04	T. 20 S., R. 33 E.
NM 22426	6-19-74	Kerr-McGea Corp.	2,338.80	T. 20 S., R. 33 E. & T. 21 S., R. 31 E. & T. 21 S., R. 32 E.
NM 24595	1-24-75	Amax Chemical Corp.	2,520.00	T. 19 S., R. 33 E. & T. 20 S., R. 33 E.
NM 24596	1-24-75	Amax Chemical Corp.	2,000.00	T. 24 S., R. 30 E.
NM 24597	1-24-75	Amax Chemical Corp.	2,360.00	T. 21 S., R. 32 E.
NM 24598	1-24-75	Amax Chemical Corp.	1,840.00	T. 21 S., R. 32 E.
NM 24599	1-24-75	Amax Chemical Corp.	2,280.00	T. 20 S., R. 33 E.
NM 24600	1-24-75	Amax Chemical Corp.	1,600.00	T. 20 S., R. 33 E.
NM 24601	1-24-75	Amax Chemical Corp.	2,560.00	T. 19 S., R. 33 E. & T. 20 S., R. 33 E.
NM 24938	3-7-75	National Potash Company	800.00	T. 20 S., R. 31 E.
NM 25225	3-31-75	Noranda Exploration Inc.	2,360.00	T. 20 S., R. 33 E.

16 Total Competitive Applns.

26,178.84 Total Acres

Serial Number	Non-Competitive Appln. for Potash Lease	Applicant's Name	Number of Acres	Primary Township and Range
NM 24522	1-15-75	Mississippi Chemical Corp.	800.00	T. 21 S., R. 30 E.

1 Total Non-Competitive Appln.

800.00 Total Acres

Acreage for Eddy and Lea Counties

EDDY COUNTY*

	ACREAGE	PERCENT
Co. Total	2,667,100	100.0
Federal	1,647,700	61.8
USFS	(134,739)	
NPS	(51,000)	
BLM	(1,461,961)	(54.8% of total)
State	491,400	18.4
Private	528,000	19.8

LEA COUNTY*

Co. Total	2,811,200	100.00
Federal		
(All BLM)	466,900	16.6
State	886,800	31.6
Private	1,457,500	51.8

*N.M. Blue Book 1967-1968

APPENDIX E-2

GRAZING ALLOTMENTS

Potash Study Area

Allotment	Acres NRL**	Animal Unit Months	Cows Year-Long
L. H. Bates	50,118	10,356	846
John Williams	10,442	1,654	137
Virgil Linam Est.	9,884	1,515	130
Blaine Haines	1,609	228	19
A. H. Rains	6,100	960	80
J. D. Spears	5,965	972	81
J. D. Spears	17,908	2,364	197
T. L. London	270	53	4
Arthur Pue	2,810	552	46
Cliff Key	22,246	3,684	301
Claud West	950	80	6
Lawrence Calley	14,030	1,752	146
J. M. Farms	4,090	420	35
Mobley & Carbb	12,427	1,992	162
Willow Lake Ranch	2,640	269	22
James Newmeyer	2,310	140	11
Delaware Ranch	19,823	3,471	289
Roy Lindsay	17,335	3,000	245
W. D. Johnson	7,410	816	68
Buck Jackson	53,560	11,616	968
Scharbauer Cattle Company	20,281	3,528	294
Mack Smith	12,638	2,604	217
T. T. Sanders	66,350	13,524	1,103
N. T. Roberts	1,600	324	27
D. C. Berry Est.	15,426	3,495	520
Caviness Cattle Company	15,288	2,179	181
G. H. Bingham	14,346	3,208	203
Tom Bingham	3,270	1,116	93
Georgia Campbell	4,837	972	79
Kennith and William Smith	47,834	7,896	658
W. M. Snyder Ranches LTD.	160,683	29,570	3,330
Charles James	24,374	5,124	418
W. M. Brininstool	11,967	2,388	199
Malcolm and Kate Madua	3,273	924	77
Madera - McDonald	19,125	3,420	279
Mack Campbell	5,838	1,356	113
W. A. Maddox*	1,040	204	17
Julia Williams	630	110	9
Marchant Livestock Company*	14,555	2,968	
Virgil Linam Est.*	1,443	270	
TOTALS	716,728	132,395	11,721

* Denotes Section 15 Lease
**National Resource Lands

TABLE OF SURFACE AND SUBSURFACE LAND OWNERSHIP AREA IN ACRES

		Surface Estate				Mineral Estate	
Township	Range	National Resource Lands	State Land	Private Land	Total Acres in Study Area	Federal Minerals	Other Minerals
18 S.	30 E.	19,933.00	2,675.98	389.96	22,998.94	20,320.94	2,678.00
18 S.	31 E.	20,036.26	2,880.56		22,916.82	20,196.26	2,720.56
18 S.	32 E.	18,187.76	2,641.40	2,242.04	23,071.20	20,187.92	2,883.28
18 S.	33 E.	13,412.68	4,160.28	5,531.38	23,104.34	16,294.16	6,810.18
19 S.	30 E.	20,020.70	2,561.52	440.00	23,022.22	20,340.70	2,681.52
19 S.	31 E.	20,852.54	1,919.40	240.00	23,011.94	21,012.54	1,999.40
19 S.	32 E.	20,402.13	2,559.68	50.00	23,011.81	20,452.13	2,559.68
19 S.	33 E.	16,003.46	2,656.32	4,480.00	23,139.78	20,163.46	2,976.32
19 S.	34 E.	15,845.50	6,927.40	360.00	23,132.90	15,845.50	7,287.40
XX20 S.	28 E.	1,280.00			1,280.00	1,280.00	
20 S.	29 E.	21,999.01	643.76	300.95	22,943.72	22,299.96	643.76
20 S.	30 E.	18,590.16	3,360.27	1,080.29	23,030.72	18,790.16	4,240.56
20 S.	31 E.	20,384.19	1,914.36	680.00	22,978.55	20,384.19	2,594.36
20 S.	32 E.	18,344.13	2,119.60	2,565.00	23,028.73	18,869.13	4,159.60
20 S.	33 E.	18,043.74	3,398.96	1,600.59	23,043.29	18,683.74	4,359.55
20 S.	34 E.	12,492.17	1,603.20	8,320.11	22,415.48	19,372.17	3,043.31
20 S.	35 E.	1,323.42	1,282.52	20,449.98	23,055.92	8,609.83	14,446.09
21 S.	29 E.	20,538.24	2,700.96	1,261.44	24.500.64	20,799.00	3.701.64
21 S.	30 E.	19,087.27	5,823.80	120.00	25,031.07	19,087.27	5,943.80
21 S.	31 E.	19,556.89	3,329.52	1,925.08	24,811.49	20,686.93	4,124.56
21 S.	32 E.	21,979.05	1,606.55	1,465.06	25,050.66	23,370.66	1,680.00
21 S.	33 E.	626.39	17,346.26	6,867.99	24,840.64	1,618.08	23,222.56
21 S.	34 E.		20,256.42	4,629.48	24,885.90		24,885.90
22 S.	29 E.	19,926.84	2,840.24	280.00	23,047.08	20,046.84	3,000.24
22 S.	30 E.	17,771.28	5,083.92	200.00	23,055.20	17,771.28	5,283.92

TABLE OF SURFACE AND SUBSURFACE LAND OWNERSHIP
AREA IN ACRES

		Surface Estate				Mineral Estate	
Township	Range	National Resource Lands	State Land	Private Land	Total Acres in Study Area	Federal Minerals	Other Minerals
22 S.	31 E.	20,480.44	2,559.48		23,039.92	20,480.44	2,559.48
22 S.	32 E.	19,623.07	2,640.00	884.32	23,147.39	20,302.64	2,844.75
22 S.	33 E.	8,160.04	11,851.41	2,946.96	22,958.41	14,720.56	8,237.85
22 S.	34 E.	6,075.41	11,317.07	5,636.84	23,029.32	13,885.87	9,143.45
XX23 S.	29 E.	10,986.94	2,678.78	4,151.85	17,817.57	14,498.79	3,318.78
*23 S.	30 E.	17,923.38	4,325.90	200.00	22,449.28	18,043.84	4,405.44
23 S.	31 E.	20,710.22	1,438.84	922.09	23,071.15	21,792.31	1,278.84
23 S.	32 E.	21,379.87	1,758.47	40.00	23,178.34	19,499.87	3,678.47
XX24 S.	29 E.	3,199.10	640.00		3,839.10	3,199.10	640.00
24 S.	30 E.	20,447.24	2,560.66	40.00	23,047.90	19,807.24	3,240.66
24 S.	31 E.	20,317.60	2,578.93	125.00	23,021.53	20,322.60	2,698.93
24 S.	32 E.	19,136.49	2,399.84	1,640.00	23,176.33	21,936.49	1,239.84
XX25 S.	29 E.	10,237.87	3,198.88		13,436.75	10,237.87	3,198.88
25 S.	30 E.	17,553.96	5,087.01	400.55	23,041.52	17,873.96	5,167.56
25 S.	31 E.	21,084.37	1,960.00		23,044.37	21,084.37	1,960.00
25 S.	32 E.	20,480.15	2,560.96		23,041.11	20,480.15	2,560.96
XX26 S.	29 E.	6,951.99	1,006.01	200.00	8,158.00	7,262.40	895.60
XX26 S.	30 E.	18,880.32	1,795.76	80.00	20,756.08	18,960.32	1,795.76
XX26 S.	31 E.	18,246.71	1,320.00	1,202.00	20,768.71	18,526.71	2,242.00
XX26 S.	32 E.	18,763.84	1,838.12	160.75	20,762.71	18,844.19	1,918.52
TOTAL		717,275.82	167,809.00	84,109.71	969,874.53	768,922.57	200,951.96

* 680 Acres withdrawn by the Atomic Energy Commission for project Gnome are not included in the totals for this township.

XX Part of township not in the study area

APPENDIX 4

Summary of potash refinery production and operating data

Company	Ore processed tons/day	Potash products, tons/yr	Production, tons/day	Discard of salts and clay, tons/day	Analysis of tail brine, pct						Consumed per ton product		
					K	Na	Mg	Ca	Cl	SO_4	Electricity, kW-hr	Natural gas, Mcf	Water, gal
IMC	14,000	800,000	KCl 800 SPM 1,800 K_2SO_4 500	10,900	2.2	8.5	0.5	0.03	15	2	110	2.7	1,800
Duval	7,000	675,000	KCl 600 KMag 1,000 K_2SO_4 300	5,100	2.5	7.5	.9	.1	14	3.4	80	1.4	980
PCA	9,000	860,000	KCl 2,800	6,200	1.3	3.0	.1	.2	6	.4	98	2.8	480
NPC	5,200	500,000	KCl 1,500	3,700	1.5	4.7	.2	.1	9	.5	82	1.1	813
AMAX	10,000	700,000	KCl 2,200	7,800	1.8	9.0	.4	.1	16	.4	75	.6	950
Mississippi	2,400	120,000	KCl 400	2,000	.6	2.8	.1	.1	3	.3	90	.5	2,000
Kerr-McGee	8,000	550,000	KCl 1,700	6,300	2.4	8.2	.4	.1	15	1.4	125	3.4	1,300

APPENDIX 5

Carlsbad Potash Study Area - Analysis of Potash Operations, Production, Employment, State and Local Tax, Local Expenditures (Annual Averages).

Company	Average Annual Production Potash (tons)	Average Annual Payroll (dollars)	Average Annual Employment (number)	Average Annual State and Local Tax (dollars)	Average Annual Local Expenditures (dollars)
NPC	496,000	2,538,000	244	427,171	2,000,000
IMC	800,000	6,500,000	550	470,000	2,000,000
MCC	120,000	2,200,000	160	235,000	1,500,000
PCA	860,000	6,100,000	550	430,000	1,500,000
Kerr-McGee	550,000	6,200,000	400	690,000	4,000,000
Duval	675,000	3,500,000	475	258,000	3,000,000
AMAX	700,000	3,700,000	370	440,000	2,100,000
Study Area Totals	4,201,000	30,738,000	2,749	2,950,173	21,100,000
Study Area Average	600,140	4,391,100	390	421,455	3,014,285

Source: Individual Company Estimates

APPENDIX F

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action Construction — All construction efforts ie. roads & drill pads for exploration refineries & their support facilities

2. Stages of implementation

3. DISCRETE OPERATIONS: Site Specific / Regional / Miss. Chem.

	4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS Site Specific	Regional	Miss. Chem.			6. REMARKS
I. NONLIVING COMPONENTS	A. AIR						
	Particulates	H-	L-	H-			
	Gas, CO, NOx	L-	L-	L-			
	Noise	H-	L-	H-			80 – 90 db Short term during construction
	B. LAND						
	Erosion, Compaction	L-	L-	L-			Bull dozing
	Grazing	L-	L-	L-			
	Depth, structure, nutrients	M-	L-	M-			
	Soil Pollutants	M-	L-	M-			
	Compatibility	L-	X	L-			
	Suitability	L-	X	L-			
	Mineral Resources	L-	L-	L-			
	C. WATER						
	Cap rock	X	X	X			Impacts unknown
	Brine leakage	X	X	X			
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						

(Continued on reverse)

APPENDIX F CONTINUED

DISCRETE OPERATIONS

	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS Site Specific	Regional	Miss. Chem.			REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*						
	Vegetation	H-	L-	H-			On-site destruction
	C. ANIMALS *(Aquatic)*						
	D. ANIMALS *(Terrestrial)*						
	Small mammals and reptiles	H-	L-	H-			On-site destruction
	Birds	L-	L-	L-			On-site destruction
	Intevertebrates	H-	L-	H-			On-site destruction
III. INTERRE-LATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	H-	L-	H-			
	Food Relationships	H-	L-	H-			
	Community Relationships	H-	L-	H-			
IV. HUMAN VALUES	A. LANDSCAPE CHARACTER						
	Visual	L-	L-	M-			Miss Chem. view of bluffs
	Recreation	0	0	L -			
	Open Space		L-	H-			
	Historical		X	X			
	B. SOCIOCULTURAL INTERESTS						
	Social Welfare	L+	M+	L+			Employment, goods, services
	Attitudes	H+	H+	H+			Most citizens favor the Industry
	Archaeology	M-	M-	H-			Site destruction & increased accessibility

INSTRUCTIONS

1. *Action* – Enter action being taken, analytic step for which worksheet is being used, environmental viewpoint of impact, and any assumptions relating to impact.
   a. Worksheet is normally used to analyze *"Anticipated Impacts"* of action; *however,* it may be used to analyze *"Residual Impacts."* Worksheets may also be used to compare impacts before and after mitigating measures are applied.
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   c. Assumptions may be made to establish a base for analysis *(e.g. estimated time periods, season of year, etc.).*

2. *Stages of Implementation* – Identify different phases of proposed project *(e.g. a road project consists of survey, construction, use, and maintenance stages).*

3. *Discrete Operations* – Identify separate actions comprising a particular stage of implementation *(e.g. the construction stage of the road project has the discrete operations of clearing, grading, and surfacing).*

4. *Elements Impacted* – Enter under appropriate heading all environmental elements susceptible to impact from action and alternatives. Relevant elements not contained in the digest should also be entered. See BLM Manual 1791, Appendix 2, Environmental Digest.

5. *Anticipated Impact* – Evaluate anticipated impact on each element and place an entry in the appropriate square indicating degree of impact as low (L), medium (M), high (H), no impact (O), or unknown or negligable (X). Preceed each entry by a plus (+) or minus (–) sign indicating a beneficial or adverse type of impact. If type of impact reflects a matter of opinion or is not known, *do not* preceed with a sign. For example, construction of a wind mill on open range has a definite visual impact; *however,* to some people the effect is detrimental while to others it is an improvement. By not entering a plus (+) or minus (–) sign the worksheet is kept factual and unbiased. If both degree and type of impact are unknown, place an (x) in the appropriate square.
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   b. It is recognized that some environmental elements may defy accurate measurement or in-depth analysis within current Bureau capabilities or expertise. The nature of the action as well as type and degree of impact should guide in the decision to seek outside expertise or assistance.

6. *Remarks* – Enter clarifying information.

APPENDIX F CONTINUED

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Exploration

2. Stages of implementation Drilling, rig set-up, drilling casing, pulling casing, monument set-up.

3. DISCRETE OPERATIONS

4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED		5. ANTICIPATED IMPACTS					6. REMARKS
		Site Specific	Regional	Miss Chem.			
I. NONLIVING COMPONENTS	A. AIR						
	Particulate matter	L-	L-	L-			
	Noise	M-	L-	M-			
	CO	L-	L-	L-			
	B. LAND						
	Erosion compaction	L-	L-	L-			
	Grazing	L-	L-	L-			Long term destruction of small areas.
	Depth, structure, nutrients	M-	L-	M-			Disturbed by operations
	Soil pollutants	L-	L-	L-			
	Compatibility	L-	X	L-			
	Suitability	L-	X	L-			
	Mineral Resources	L-	L-	L-			
	C. WATER						
	Dissolved solids	X	X	X			Negligible residual salts
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						

(Continued on reverse)

Form 1790-3 (June 1974)

DISCRETE OPERATIONS

COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED		ANTICIPATED IMPACTS: Site Specific	Regional	Miss. Chem			REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*						
	Vegetation	0	0	0			On-site destruction
	C. ANIMALS *(Aquatic)*						
	D. ANIMALS *(Terrestrial)*						
	Small mammals & reptiles	H-	0	H-			On-site habitat destroyed,noise
	Birds	L-	0	L-			On-site habitat destroyed, noise
	Invertebrates	H-	0	H-			On-site destruction (ants,Tarantulas
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession (plant & animal)	H-	0	H-			On-site plant destruction
	Food relationships	H-	0	H-			On-site (small animals,no effect on large animals)
	Community relationships	H-	0	H-			On-site disruptions.
IV. HUMAN VALUES	A. LANDSCAPE CHARACTER						
	Visual	H-	L-	0			
	Recreation	0	L+	0			Hunter & livestock operator access
	Open Space	0	L-	0			
	Historical	X	X	0			
	B. SOCIOCULTURAL INTERESTS						
	Social Welfare	L+	L+	L+			
	Attitudes	H+	H+	H+			
	Archaeology	M-	M-	H-			High density of sites, especially at the new Miss. refinery location

INSTRUCTIONS

1. *Action* — Enter action being taken, analytic step for which worksheet is being used, environmental viewpoint of impact, and any assumptions relating to impact.
   a. Worksheet is normally used to analyze "*Anticipated Impacts*" of action; *however*, it may be used to analyze "*Residual Impacts.*" Worksheets may also be used to compare impacts before and after mitigating measures are applied.
   b. State viewpoint that best describes environmental impact. For example, a fence viewed down the fence line has greater impact than the same fence viewed over an entire allotment. Generally, narrow viewpoints better illustrate specific impacts than will broad viewpoints.
   c. Assumptions may be made to establish a base for analysis *(e.g. estimated time periods, season of year, etc.)*.
2. *Stages of Implementation* — Identify different phases of proposed project *(e.g. a road project consists of survey, construction, use, and maintenance stages)*.
3. *Discrete Operations* — Identify separate actions comprising a particular stage of implementation *(e.g. the construction stage of the road project has the discrete operations of clearing, grading, and surfacing)*.
4. *Elements Impacted* — Enter under appropriate heading all environmental elements susceptible to impact from action and alternatives. Relevant elements not contained in the digest should also be entered. See BLM Manual 1791, Appendix 2, Environmental Digest.
5. *Anticipated Impact* — Evaluate anticipated impact on each element and place an entry in the appropriate square indicating degree of impact as low (L), medium (M), high (H), no impact (O), or unknown or negligable (X). Preceed each entry by a plus (+) or minus (-) sign indicating a beneficial or adverse type of impact. If type of impact reflects a matter of opinion or is not known, *do not* preceed with a sign. For example, construction of a wind mill on open range has a definite visual impact; *however*, to some people the effect is detrimental while to others it is an improvement. By not entering a plus (+) or minus (-) sign the worksheet is kept factual and unbiased. If both degree and type of impact are unknown, place an (x) in the appropriate square.
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   b. It is recognized that some environmental elements may defy accurate measurement or in-depth analysis within current Bureau capabilities or expertise. The nature of the action as well as type and degree of impact should guide in the decision to seek outside expertise or assistance.
6. *Remarks* — Enter clarifying information.

U.S. GOVERNMENT PRINTING OFFICE 1974 — 781-866

Coal

APPENDIX F CONTINUED

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Mining & Mine Development

2. Stages of implementation

3. DISCRETE OPERATIONS

4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED		5. ANTICIPATED IMPACTS Site Specific	Regional	Miss. Chem.			6. REMARKS
I. NONLIVING COMPONENTS	A. AIR						
	Surface Particulates	L-	0	L-			
	Underground Particulates	L-	0	L-			
	CO	L-	0	L-			
	B. LAND						
	Contaminants	M-	L-	M-			On-site 20 acres
	Erosion	M-	L-	M-			On-site
	Use Compatability	H-	L-	H-			Recreation, grazing, wildlife, etc.
	Geologic Stratification	L-	L-	L-			Due to Subsidence
	Mineral Resources	H-	H-	H-			Depletion of reserves
	C. WATER						
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						

	DISCRETE OPERATIONS	Site Specific	Regional	Miss. Chem.			
	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS					REMARKS
II. LIVING COMPONENTS *(Con.)*	B. PLANTS *(Terrestrial)*						
	Vegetation	H-	O	H-			Shaft, waste dump
	C. ANIMALS *(Aquatic)*						
	D. ANIMALS *(Terrestrial)*						
	Mammals,Birds,Reptiles	H-	X	H-			Habitat destroyed
	Invertebrates						
	Man	L-	L-	L-			Health
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	H-	L-	H-			Destruction of vegetation
IV. HUMAN VALUES	A. LANDSCAPE CHARACTER						
	Open Space	L-	L-	H-			New Miss. site quite scenic
	Visual	L-	L-	L-			Headframes add intrest, not new Miss.
	Recreation	O	O	O			
	Historical	O	X	X			
	B. SOCIOCULTURAL INTERESTS						
	Social Welfare	M+	H+	M+			Employment, goods, services
	Attitudes	H+	H+	H+			Most citizens favor the industry
	Archaeology	-M	L-	H-			Site destruction & increased
		-L-					accessibility

INSTRUCTIONS

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6. *Remarks* – Enter clarifying information.

APPENDIX F CONTINUED

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Refining

2. Stages of implementation

3. DISCRETE OPERATIONS

4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS: Site Specific	Regional	Miss. Chemical			6. REMARKS
I. NONLIVING COMPONENTS						
A. AIR						
Outside: Particulates, Visual	M-	L-	M-			
CO, NO_x, Hydrocarbons	M-	L-	M-			
HCL	H-	M-	H-			
In-plant: Noise	L-	O	L-			
B. LAND						
Contaminants	M-	L-	M-			
Erosion	M-	L-	M-			
Depth	L-	L-	L-			
Nutrients	L-	L-	L-			
Mineral Resources	L-	L-	L-			Loss of Minerals - to waste pile
C. WATER						
Cap Rock	H-	H-	H-			Water Use & Depletion
Leakage	X-	L-	X-			Potential of adding brine to river
II. LIVING COMPONENTS						
A. PLANTS *(Aquatic)*						

(Continued on reverse)

Form 1790-3 (June 1974)

Refining

	DISCRETE OPERATIONS	Site Specific	Regional	Miss. Chemical			
	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS					REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*						
	Vegetation	H-	L-	H-			On-site destruction, species change
		H+					Wildlife
	C. ANIMALS *(Aquatic)*						
	D. ANIMALS *(Terrestrial)* Mammals, Birds, Reptiles						
	Invertebrates	+H -H					-H species change +H wildlife
	Mammals	X-					Noise, Air, Amines
III. INTERRE-LATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	H-	L-	H-			
	Food Relationships	H-	L-	H-			
	Community Relationships	H-	L-	H-			
IV. HUMAN VALUES	A. LANDSCAPE CHARACTER Open Space		L-	H-			Greatly depends on refining location
	Visual	H-	M-	M-			
	Recreation	M-	L-	L-			
	Historical	O	X	X			
	B. SOCIOCULTURAL INTERESTS Social Welfare	M+	H+	M+			Employment, goods, services
	Attitudes	H+	H+	H+			Most citizens favor the industry
	Archaeology	H-	H-	H-			Refineries, salt piles, brine
							ponds, etc.

INSTRUCTIONS

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6. *Remarks* – Enter clarifying information.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action
Support roads, railroads, garbage dumps, powerlines, water lines, natural gas lines, septic tanks

2. Stages of implementation

3. DISCRETE OPERATIONS

	4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS					6. REMARKS
		Site Spec.	Regional	Miss. Chem.			
I. NONLIVING COMPONENTS	A. AIR						
	Particulates	L-	0	L-			Existing situation is already H-
	CO, NO_x, Hydrocarbons	L-	0	L-			Ambient Air Standards being
	Noise	L-	0	L-			exceeded
	B. LAND						
	Erosion	L-	L-	L-			
	Compatability	L-	L-	L-			
	Mineral Resources	L-	L-	L-			
	C. WATER						
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						

(Continued on reverse)

DISCRETE OPERATIONS

	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS Site Specific	Regional	Miss. Chemical			REMARKS
II. LIVING COMPONENTS (*Con.*)	B. PLANTS (*Terrestrial*)						
	Vegetation	0	0	0			
	C. ANIMALS (*Aquatic*)						
	D. ANIMALS (*Terrestrial*)						
	Mammals etc.	0	0	0			
III. INTERRELATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	H-	L-	H-			
	Food Relationships	H-	L-	H-			
	Community Relationships	H-	L-	H-			
IV. HUMAN VALUES	A. LANDSCAPE CHARACTER						
	Open Space	L-	L-	H-			
	Visual	H-	M-	H-			
	Recreation	L+	L+	X			
	Historical	0	X	L+			
	B. SOCIOCULTURAL INTERESTS						
	Social Welfare	M+	H+	M+			Employment, goods & services
	Attitudes	H+	H+	H+			most citizens favor the industry
	Archeology	H-	H-	H-			site destruction & increased accessibility.

INSTRUCTIONS

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4. *Elements Impacted* – Enter under appropriate heading all environmental elements susceptible to impact from action and alternatives. Relevant elements not contained in the digest should also be entered. See BLM Manual 1791, Appendix 2, Environmental Digest.

5. *Anticipated Impact* – Evaluate anticipated impact on each element and place an entry in the appropriate square indicating degree of impact as low (L), medium (M), high (H), no impact (O), or unknown or negligable (X). Preceed each entry by a plus (+) or minus (-) sign indicating a beneficial or adverse type of impact. If type of impact reflects a matter of opinion or is not known, *do not* preceed with a sign. For example, construction of a wind mill on open range has a definite visual impact; *however*, to some people the effect is detrimental while to others it is an improvement. By not entering a plus (+) or minus (-) sign the worksheet is kept factual and unbiased. If both degree and type of impact are unknown, place an (x) in the appropriate square.
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6. *Remarks* – Enter clarifying information.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

ENVIRONMENTAL ANALYSIS WORKSHEET

1. Action

Lease Abandonment

2. Stages of implementation

3. DISCRETE OPERATIONS

	4. COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	5. ANTICIPATED IMPACTS					6. REMARKS
		Site Specific	Regional	Miss. Chemical			
I. NONLIVING COMPONENTS	A. AIR						
	Particulates	L-	0	L-			
	B. LAND						
	Erosion	L-	L-	L-			
	Contaminants	L-	L-	L-			
	Use Compatibility	L-	L-	L-			
	Mineral Resources	L-	L-	L-			
	C. WATER						
II. LIVING COMPONENTS	A. PLANTS *(Aquatic)*						

(Continued on reverse)

	DISCRETE OPERATIONS	Site Specific	Regional	Miss Chemical			
	COMPONENTS, SUBCOMPONENTS, AND ELEMENTS IMPACTED	ANTICIPATED IMPACTS					REMARKS
II. LIVING COMPONENTS (Con.)	B. PLANTS *(Terrestrial)*						
	Vegetation	L+	0	L+			Some land going back into productio
	C. ANIMALS *(Aquatic)*						
	D. ANIMALS *(Terrestrial)*						
	Mammals, etc.	L+	X	L+			
III. INTERRE-LATIONSHIPS	A. ECOLOGICAL PROCESSES						
	Succession	H-	L-	H-			
	Food Relationships	H-	L-	H-			
	Community Relationships	H-	L-	H-			
IV. HUMAN VALUES	A. LANDSCAPE CHARACTER						
	Open Space	L+	L+	L+			
	Visual	L+	M+	M+			
	Recreation	L+	L+	L+			
	Historical	0	X	X			
	B. SOCIOCULTURAL INTERESTS						
	Social Welfare	L+	H-	L+			Reduction of employment would
	Attitudes	H-	H-	H-			mean closing a plant
	Archeology	0	0	0			

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GLOSSARY

Acre-foot. The quantity of a material that will cover an area of one acre to a depth of one foot.

Alluvium. Clay, silt, sand, and gravel or other rock material transported by flowing water and deposited as sorted or semi-sorted sediments.

Animal Unit Month. The amount of forage necessary for the sustenance of one cow or its equivalent for a period of one month.

Aquatic Wildlife. All wildlife found which live entirely within or that depend upon an aquatic environment for their major life function.

Aquifer. A layer of rock, sand or gravel that contains water and will deliver it in usable quantities to wells.

Archeological Sites. Any location where American Indian or Mexican artifacts or evidence of use and/or occupation by them are found. Historically documented aboriginal sites are also included.

Aspect. (Of vegetation) dominant visual vegetative composition of an area.

Brackish water. Impotable water or brine with an indeterminate concentration of dissolved solids.

Breccia. A type of rock with angular fragments due to breakage through some geologic process.

Brine. Aqueous solution with a greater concentration of dissolved solids than sea water. This concentration is greater than 35,000 milligrams per liter.

Caliche. (1) A layer near the surface, more or less cemented by secondary carbonates of calcium or magnesium precipitated from the soil solution. It may occur as a soft thin soil horizon, as a hard thick bed just beneath the solum, or as a surface layer exposed by erosion. Not a geologic deposit. (2) Alluvium cemented with sodium nitrate, chloride and/or soluble salts.

Clastic. A clastic rock is one composed of fragmental or detrital material, most commonly sandstone or shale.

Cultural Resources. Historical, prehistoric (archeological) and architectural sites, structures and objects.

Crop out. (verb) A place where rock usually of a given formation or lithologic type, is exposed at the land surface.

Dip. The angle at which a stratum is inclined from the horizontal.

Dispersed soil. Soil in which the clay readily forms a colloidal soil. Dispersed soils usually have low permeability. They tend to shrink, crack, and becomes hard when dry and to slake and become plastic when wet.

Dissolved solids. The concentration of all mineral constituents in water.

Dosimeter. An instrument or device for measuring doses of X-rays or radioactivity.

Drainage. (1) The processes of the discharge of water from an area of soil by sheet or stream flow (surface drainage) and the removal of excess water from within soil by downward flow through the soil (internal drainage). (2) The means for effecting the removal of water from the surface of soil and from within the soil, i.e., sloping topography on stream channel (surface drainage) and open ditches, underground tile lines, or pumped wells (artificial drainage).

ECS10^3. Electrical conductivity in millimhos/cm. (Value in mhos/cmX10^3).

Erosion. The wearing away of the earth's surface by forces of water and wind.

Evaporite minerals. Minerals formed in nature by the evaporation of the solution which contained them.

Flocculants. Produces floccule or other aggreate formation esp. in soil.

Formation. A distinctive group of rocks selected as a convenient unit for geologic mapping, description, and reference.

Fresh water. Potable water with a known or assumed dissolved solid concentration less than 1,000 milligrams per litre.

Frother. Methyl isobutyl carbinol, MlBC.

Grazing capacity. The total animal unit months of forage available from a tract or tracts of forage land during a given period.

Ground Water Water derived from atmospheric precipitation which saturates rock openings at and below the water table. Also all water below the ground surface.

Gully. A miniature valley or gorge worn in the earth, a small ravine in the face of a precipice; a wooded hollow with steep sides, as a result of erosion.

Gypsum. A widely distributed mineral $CaSO_4 \cdot 2H_2O$ consisting of hydrous calcium sulfate that is colorless when pure, occurs massive or in the form of monoclinic crystals that easily split into folia, and is used chiefly as a soil amendment, as a retarder in portland cement, and in making plaster of Paris.

Halite. NaCl, sodium chloride.

Historical Sites. Any location where artifacts or other evidence of use by other than aboriginal people occur. Also included are locations where a documented historical event took place even though no physical evidence of it remains.

Hydrous Evaporite minerals. Evaporite minerals which contain molecules of water as a part of their chemical composition.

Infiltration. The downward entry of water into soil.

Karst. A limestone region marked by sinks and interspersed with abrupt ridges, irregular protuberant rocks, caverns, and underground streams.

Kerf. A slit or notch in cutting usually by a saw or cutting torch; the width of that cut.

Langbeinite. $K_2SO_4 \cdot 2MgSO_4$, potassium magnesium sulfate, a potash ore.

Launder. A conduit or trough for water or other liquids.

Leaching. The process of removal of soluble material by the passage of water through soil.

Lime Zone. A zone of precipitated calcium carbonate, or of other material cemented by precipitated calcium carbonate.

Log. A graphic presentation of the lithologic or straeographic units traversed by a bore hole.

Member. A division of a geologic formation generally of distinct lithology over a wide area.

Mesic. Of a habitat, having or characterized by a moderate amount of moisture.

Milligrams per litre. An expression of concentration of a specific or several constituents in water. Except for brines it is approximately equivalent to parts per million. A concentration of 0.1 milligram per liter of common salt is equivalent to a few grains of table salt in a volume slightly more than 1 quart.

Mudstone. A general descriptive word for rocks containing clay, silt, siltstone, shale and other fine grained material.

Outcrop. (noun) A place where rock, usually of a given formation or lithologic type, is exposed.

Paleontological Sites. Any location containing fossil remains of plants or animals.

Percolation. A qualitative term applying to the downward movement of water through soil. Especially, the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of one or less.

Permeability. (1) Qualitative. The quality or state of a porous medium relating to the readiness with which such a medium conducts or transmits fluids. (2) Quantitative. The specific property governing the rate or readiness with which a porous medium transmits fluids under standard conditions. The equation used for expressing the flow should take into account the properties of the fluid so that proper measurements on a given medium give the same permeability value for all fluids that do not alter the medium.

pH. Reading of saturated soil paste; saturation extract; 1 or 1:5 soil - water suspension. Measured with glass electrode unless otherwise specified.

Phreatophytes. A plant that habitually obtains its water supply from the zone of saturation, either directly or through the capillary fringe.

Polyhalite. $2CaSO_4.K_2SO_4.MgSO_4.2H_2O$ calcium, potassium, magnesium, sulfate.

Porosity. The ratio of the volume of pores to the total volume.

Potash ore. Ore containing the minerals sylvite (K_2O - potassium chloride) or langbenite (K_2SO_4 $2MgSO_4$ - potassium magnesium sulfate).

Potentiometric Surface. An imaginary surface that coincides with the statio level of water in a aquifer. Potentiometric presure is the presure necessary to push water in confined aquifers up to the potentiometric surface.

Productive soil. A soil in which the chemical, physical and biological conditions are favorable for the economic production of crops suited to a particular area.

Productivity, soil. The capacity of the soil, in its normal environment, for producing a specified plant or sequence of plants under a specified system of management. The "Specified" limitations are necessary since no soil can produce all crops with equal success nor can a single system of management produce the same effect on all soils. Productivity emphasizes the capacity of the soil to produce crops and should be expressed in terms of yields.

Profile soil. A vertical section of the soil through all its horizons and extending into the parent material.

Recharge. The process by which water moves into an aquifer, or the amount of water that moves into an aquifer.

Reduction Spots. More or less spherical and discolored features in rocks possibly due to chemical reactions where some chemical constituents such as iron have been reduced in valence.

Residium. Rock composed of material so fine as to be unidentifiable with an optical microscope.

Rill. Groove, furrow, a small depression or eroded channel made by small stream.

Saline-Alkali Soil. A soil containing sufficient exchangeable sodium to interfere with the growth of most crop plants and containing appreciable quantities of soluble salts. The exchangeable - sodium - percentage is greater than 15, and the electrical conductivity of the saturation extract is greater than 4 mmhos. per centimeter (at 25°C). The pH reading of the saturated soil is usually less than 8.5.

Saline soil. A non-alkali soil containing soluble salts in such quantities that they interfere with the growth of most crop plants. The electrical conductivity of the saturation extract is greater than 4 mmhos per centimeter (at 25°C), and the exchangeable - sodium - percentage is less than 15. The pH reading of the saturated soil is usually less than 8.5.

Saline water. In this report saline water has a concentration of dissolved solids greater than 1,000 milligrams per liter.

Salt. Certain types of exchangeable ions or soluble salts, which when present, adversely modify soil for growth of most vegetation. (Includes soil having an excess of salts, or an excess of exchangeable sodium, or both).

Shale. A fine-grained sedimentary rock.

Siltstone. A sedimentary rock composed of grains intermediate in size between clay and sand.

Sink. A depression in the land surface; one having a central playa or saline lake with no drainage outlet.

Soil. (1) The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. (2) The unconsolidated mineral matter on the surface of the earth has been subjected to and influenced by genetic and environmental factors of: parent material, climatic (including moisture and temperature effects), micro- and microorganisms, and topography, all acting over a period of time and producing a product (soil) that differs from the material from which it is derived in many physical, chemical, biological and morphological properties, and characteristics.

Soluble salts. Soluble salts that occur in soils consist mostly of various proportions of the cations sodium, calcium, and magnesium, and the anions chloride and sulfate. Constituents that ordinarily occur only in minor amounts are the cation potassium and the anions bicarbonate, carbonate and nitrate. The original and, to some extent, the direct source of all the salt constituents are the primary minerals found in soils and in the exposed rocks of the earth's crust.

Surface soil. The uppermost part of the soil, ordinarely moved in tillages, or its equivalent in uncultivated soils ranging in depth from 3 or 4 inches to 8 or 10 inches. Frequen designated as the plow layer.

Swale. A low-lying stretch of land; an elongated depression inland that is at least seasonally wet, and is norma without flowing water. A low area between two ridges.

Sylvite. KCL, potassium chloride.

Topsoil. (1) The layer of soil moved in cultination; see surface soil: (2) The A Horizon. (3) The A 1 Horizon: (4) Presumably futite soil material used to top dress roadbanks, gardens and lawns.

Trap-night. One animal trap set for one night.

Unconsolidated. Formed of loose uncemented material. Ex. soil, rock slide, gravel.

Water bar. A ridge made across a hill road to direct rain water to one side.

Water table. Generally considered to be near the top of the zone of saturation in an unconfined aquifer, but this water level may fluctuate in response to several factors such as barometric pressure.

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Map I-1 Potash Lease Map

R.28E.
R.30E.
R.31E.
R.32E.
R.33E.
R.34E.
R.35E.
R.36E.
T.18S.
T.19S.
T.20S.
T.21S.
T.22S.
R.27E.
R.28E.
R.29E.
R.30E.
R.33E.
R.34E.
R.35E.
R.36E.
TO CARLSBAD 9 MILES
LEGEND
POTASH LEASES
1.- NM 016330-A
3.- LC 067319-A
4.- LC 067319-B
5.- LC 067319-C
6.- NM 0230116
7.- NM 0135063
8.- LC 065566
9.- LC 046729-A
10.- LC 046729-C
11.- LC 046729-D
12.- NM 013290
13.- NM 0121910
59.- NM 029244
61.- NM 029245
62.- NM 029243
66.- LC 041636-C
GRAMA RIDGE
RIDGE

LEGEND
POTASH LEASES

1.- NM 016330-A
2.- NM [illegible]
3.- LC 067319-A
4.- LC 067319-B
5.- LC 067319-C
6.- NM 0220116
7.- NM 0155065
8.- LC 065566
9.- LC 040729-A
10.- LC 040729-C
11.- LC 040729-D
12.- NM 013290
13.- NM 0121810
14.- NM 050249-A
15.- NM 050249-B
16.- NM 13933
17.- NM 023623
18.- NM 036791
19.- LC 064752
20.- LC [illegible]
21.- LC [illegible]
22.- LC [illegible]
23.- NM 0140970
24.- LC 073141
25.- LC 066020
26.- NM 065285
27.- NM 010026
28.- NM 0184149
29.- NM 0184150
30.- LC 061847
31.- LC 050063-B
32.- LC 062081
33.- LC 065411
34.- LC 063241-A
35.- NM 12763
36.- NM 1226
37.- NM 1225
38.- LC 065275
39.- NM 07005
40.- NM 033696
41.- NM 016101
42.- LC 043636-B
43.- LC 043636-A
44.- LC 036092-C
45.- LC 065693
46.- NM 013298-B
47.- NM 011776
48.- LC 065286
49.- LC 068397
50.- NM 013298-C
51.- NM 011777
52.- NM 015064-A
53.- NM 0554863
54.- NM 0554862
55.- NM 015064-B
56.- NM 0554864
57.- NM 18417
58.- NM 013298-A
59.- NM 029244
60.- NM [illegible]
61.- NM 029245
62.- NM 029243
63.- NM 063880
64.- LC [illegible]
65.- LC [illegible]
66.- LC 043636-C
67.- LC 036092-B
68.- LC 065494
69.- LC 044312-A
70.- NM 070607
71.- NM 03468
72.- NM 010540
73.- NM 017747
74.- NM 07755
75.- LC 044311-A
76.- LC 071869
77.- NM 015064-C
78.- NM 033696-A
79.- NM 06859
80.- NM 045410
81.- NM 15183
82.- NM 0292684
83.- NM 057287
84.- NM 045326
85.- LC 065209
86.- LC 044311-B
87.- LC 044311-C
88.- LC 044312-B
89.- LC 044312-C
90.- NM 10543
91.- NM 09118-C
92.- LC 062188
93.- NM 09118-A
94.- LC 048730-A
95.- LC 048730-B
96.- NM 0384584
97.- NM 02160
98.- NM 10544
99.- NM 10545
100.- NM 10546
101.- NM 0349889
102.- NM 0384585
103.- NM 0359160
104.- NM 6829
105.- NM 0359157
106.- NM 0359158
107.- NM 0359159
108.- NM 0349891
109.- NM 0349892
110.- NM 6830
111.- NM 0329205
112.- NM 0329206
113.- NM 0329207
114.- NM 0329208
115.- NM 0329209
116.- NM 0329210
117.- NM 13932

LEGEND

A – Mississippi Potash (Originally U.S. Borax)
B – Potash Company of America
C – International Minerals & Chemical
D – Duval Company
E – Amax Chemical Corp (Originally Southwest Potash)
F – National Potash Company
G – Kerr McGee Company

—— Carlsbad Known Potash Leasing Area Boundary
–·– Proposed Waste Disposal E.R.D.A. Project Boundary
▧ Potash Lease
▨ Potash Permit Application
▤ Potash Lease Application
■ Oil & Gas Lease

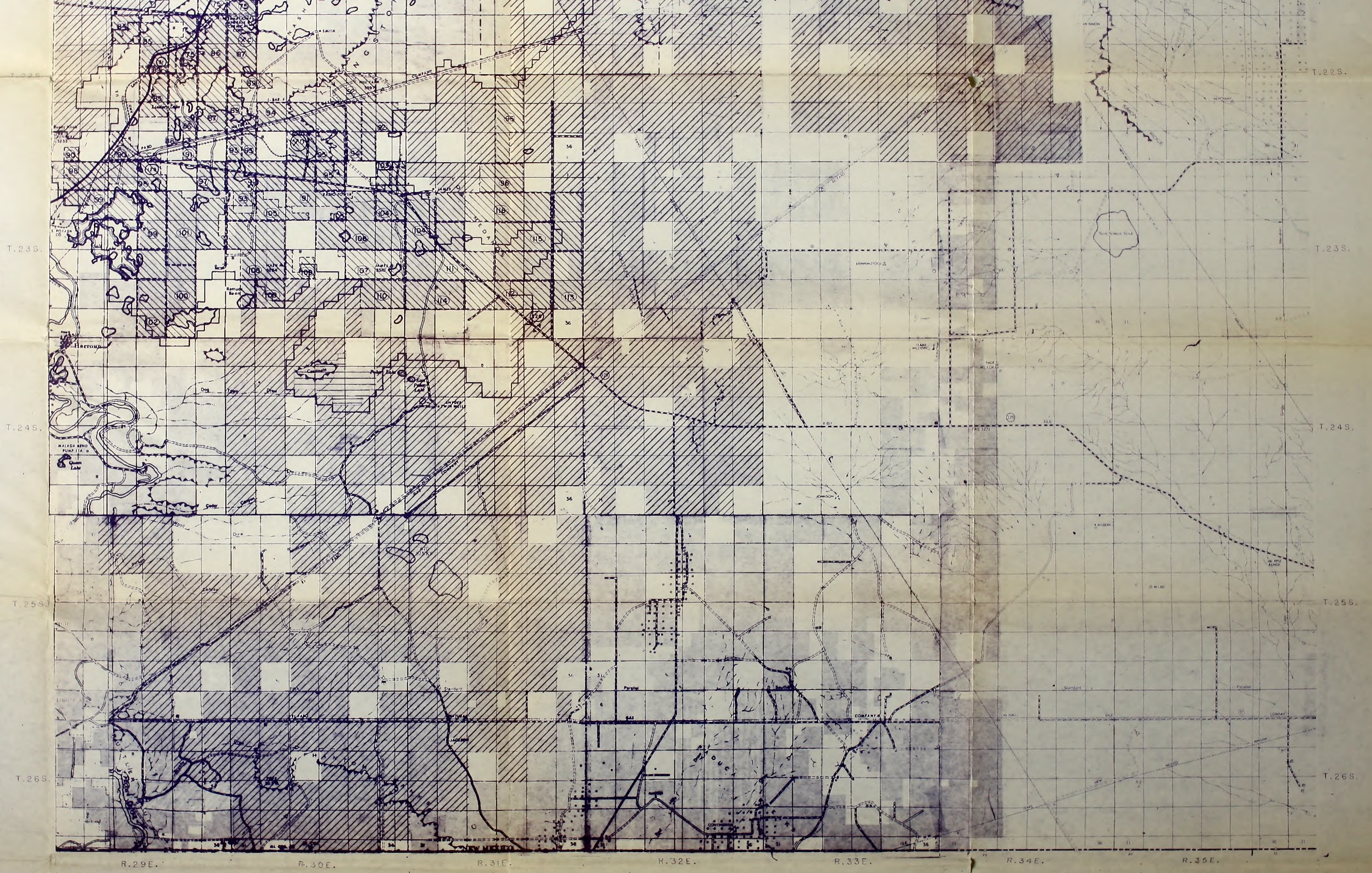


Figure I- 14 Potash Leasing
Procedures

PROSPECTING PERMIT
Application for prospecting permit filed with BLM
GS determines if area is KPA
GS determines area is KPA
BLM rejects application
GS determines area is not KPA
In consultation with GS, BLM prepares Part 23 Exam and an EAR to determine whether permit should be issued. BLM recommends stipulations and bonding.
BLM rejects application based on the findings of Part 23 Exam and EAR
BLM issues prospecting permit subject to stipulations and bonding determined in Part 23 Exam and EAR
Permittee submits exploration plan to GS
GS prepares EIA. BLM updates EAR relative to exploration if necessary.
GS with BLM concurrence approves exploration plan
GS disapproves exploration plan
Permittee does not find minerals. Prospecting permit expires or is relinquished
Permittee finds minerals and applies to BLM for preference right lease
GS evaluates mineral discovery
GS recommends rejection due to lack of significant mineral discovery
BLM rejects application
GS confirms mineral discovery and recommends stipulations and bonding
In consultation with GS, BLM updates Part 23 Exam and EAR to determine stipulations and bonding
BLM issues lease subject to BLM and GS stipulations and bonding
Lessee submits mining and reclamation plan to GS
In consultation with BLM, GS completes an EAR or EIS depending upon the significance of the mining and reclamation plan
GS with BLM concurrence approves the mining and reclamation plan
GS disapproves mining and reclamation plan
Mining followed by reclamation
Refining and other surface use followed by reclamation
Lessee files application with BLM for auxiliary Rights-of-Way (R/W) outside the lease area to serve operations on the lease area
BLM prepares Land Report and EAR. Recommends rejection or approval subject to environmental protection stipulations.
BLM Approves R/W
BLM Rejects R/W
COMPETITIVE LEASE
Application for competitive lease filed with BLM
GS determines if area is KPA
GS determines area is not KPA
BLM rejects application
GS determines area is KPA and recommends stipulations and bonding
In consultation with GS, BLM prepares Part 23 Exam and an EAR to determine whether lease should be issued. BLM recommends stipulations and bonding.
BLM rejects application based on the findings of Part 23 Exam and EAR
BLM auctions the lease subject to BLM and GS stipulations
Lessee submits exploration plan to GS
GS prepares EIA. BLM updates EAR relative to exploration if necessary.
GS disapproves exploration plan
GS with BLM concurrence approves exploration plan
Lessee submits mining and reclamation plan to GS
In consultation with BLM, GS completes an EAR or EIS depending upon the significance of the mining and reclamation plan
GS with BLM concurrence approves the mining and reclamation plan
GS disapproves mining and reclamation plan
Mining followed by reclamation
Refining and other surface use followed by reclamation
Lessee files application with BLM for auxiliary Rights-of-Way (R/W) outside the lease area to serve operations on the lease area
BLM prepares Land Report and EAR. Recommends rejection or approval subject to environmental protection stipulations.
BLM Approves R/W
BLM Rejects R/W
NONCOMPETITIVE LEASE
Application for noncompetitive lease filed with BLM
BLM requires notice of leasing interest from adjacent lessees
BLM receives a notice of leasing interest from adjacent lessees
BLM rejects noncompetitive lease application
BLM receives a disclaimer of interest from all adjacent lessees
GS determines if area is KPA and if area will make a separate mining unit
GS determines the area is KPA and will make a separate mining unit
BLM rejects noncompetitive lease application
GS determines the area is KPA and will not make a separate mining unit
GS recommends approval of noncompetitive lease and recommends stipulations and bonding
In consultation with GS, BLM prepares Part 23 Exam and an EAR to determine if lease should be issued. BLM recommends stipulations and bonding
BLM rejects application based on the findings of Part 23 Exam and EAR
BLM issues noncompetitive lease subject to BLM and GS stipulations
Lessee submits exploration plan to GS
GS prepares EIA. BLM updates EAR relative to exploration if necessary
GS disapproves exploration plan
GS with BLM concurrence approves exploration plan
Lessee submits mining and reclamation plan to GS
In consultation with BLM, GS completes an EAR or EIS depending upon the significance of the mining and reclamation plan
GS with BLM concurrence approves the mining and reclamation plan
GS disapproves mining and reclamation plan
Mining followed by reclamation
Refining and other surface use followed by reclamation
Lessee files application with BLM for auxiliary Rights-of-Way (R/W) outside the lease area to serve operations on the lease area
BLM prepares Land Report and EAR. Recommends rejection or approval subject to environmental protection stipulations.
BLM Approves R/W
BLM Rejects R/W
LEASE READJUSTMENT
Potash Lease
End of 20 year adjustment increment
BLM sends lease to GS for recommendations on revised stipulations and bonding
In consultation with GS, BLM prepares Part 23 Exam and an EAR to determine revised stipulations and bonding
BLM readjusts lease in accordance with revised stipulations and bonding
Lessee concurs with lease readjustment
Lessee does not concur with lease readjustment
Lessee appeals to IBLA
IBLA decision favors BLM
IBLA decision favors lessee
Lessee accepts IBLA decision and lease readjustment
Lessee appeals IBLA decision
BLM changes lease stipulations. Lessee accepts lease
Court decision favors BLM. Lessee accepts lease readjustment
Court decision favors lessee
BLM changes lease stipulations. Lessee accepts lease

LEGEND

BLM-------------- Bureau of Land Management
GS--------------- U.S. Geological Survey
KPA-------------- Known Potash Area
EAR-------------- Environmental Analysis Record
EIS-------------- Environmental Impact Statement
EIA-------------- Environmental Impact Analysis
IBLA------------- Interior Board of Land Appeals
Part 23 Exam----- A report required by Code of Federal Regulations Title 43 Part 23

BLM-NMSO

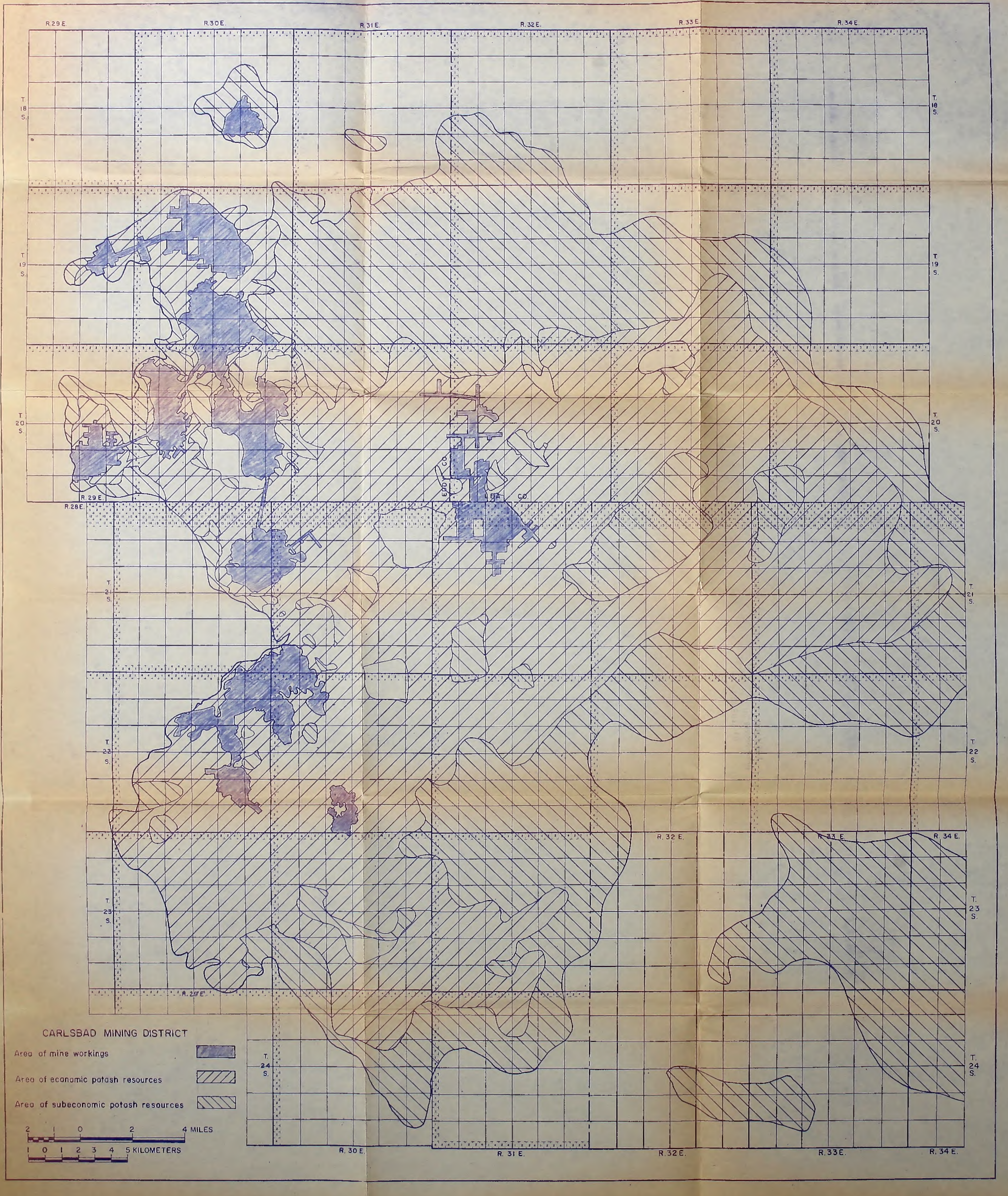
Map II-1 General Soils Map

Loco Hills
R.30 E.
R.31 E.
R.32 E.
R.33 E.
R.34 E.
R.35 E.
R.29 E.
T. 18 S.
T. 19 S.
T. 20 S.
T. 21 S.
T. 22 S.
BURTON FLAT
SALADAR FLAT
CHALK BLUFFS
R.26 E.
R.27 E
R.28 E
R.36 E.
CARLSBAD
AVALON HILLS
OCTILLO HILLS
NATIONAL POTASH CO.
Williams Sink

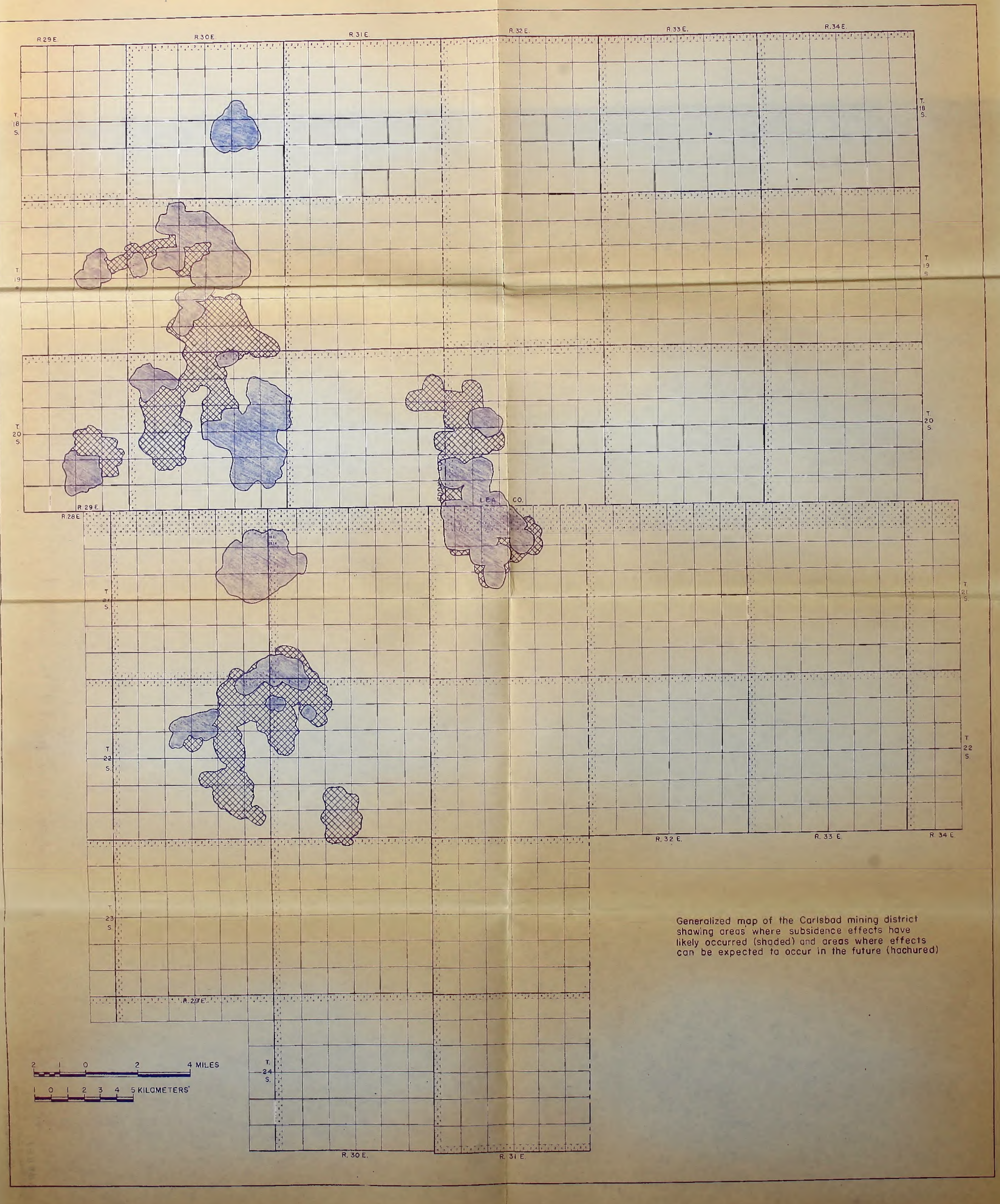
SOIL GROUPS FOR POTASH AREA

1. Shallow, Over Caliche
AW, CA, JA, KN, KO, KT, KU, MF, MU, PS, RS, RO, SA, SE, SG, SM, SN, SS, TC, TE, TF, TN, TO, UG
2. Shallow, Over Gypsiferous Rock and/or Gypsiferous Soils
CR, GA, GC, GR, RE, RG, RM, RS, RT, SR
3. Dune Sand, Deep – Hummocky
AD, BA, BB, BD, BH, BP, KA, KD, KM, PA, PD, PT, PU, PY
4. Loamy Soils, Deep
AA, BE, BF, DP, HK, LA, LN, LP, LS, MO, PC, PG, PM, RA, SF, WK
5. Deep, Over Soft Caliche (ALL IN LEA COUNTY)
MM, MN, MW, WF
6. Playas (LAGUNAS)
Pb
Tailing Piles & Brine Ponds
(NOT A SOIL GROUP)
CARLSBAD
LOVING
Harroun
Malaga
Black River Village
Otis
T. 22 S.
T. 23 S.
T. 24 S.
T. 25 S.
T. 26 S.
R. 26 E.
R. 27 E.
R. 28 E.
R. 29 E.
R. 30 E.
R. 31 E.
R. 32 E.
R. 33 E.
R. 34 E.
R. 35 E.

Map II-4 Carlsbad Mining
District

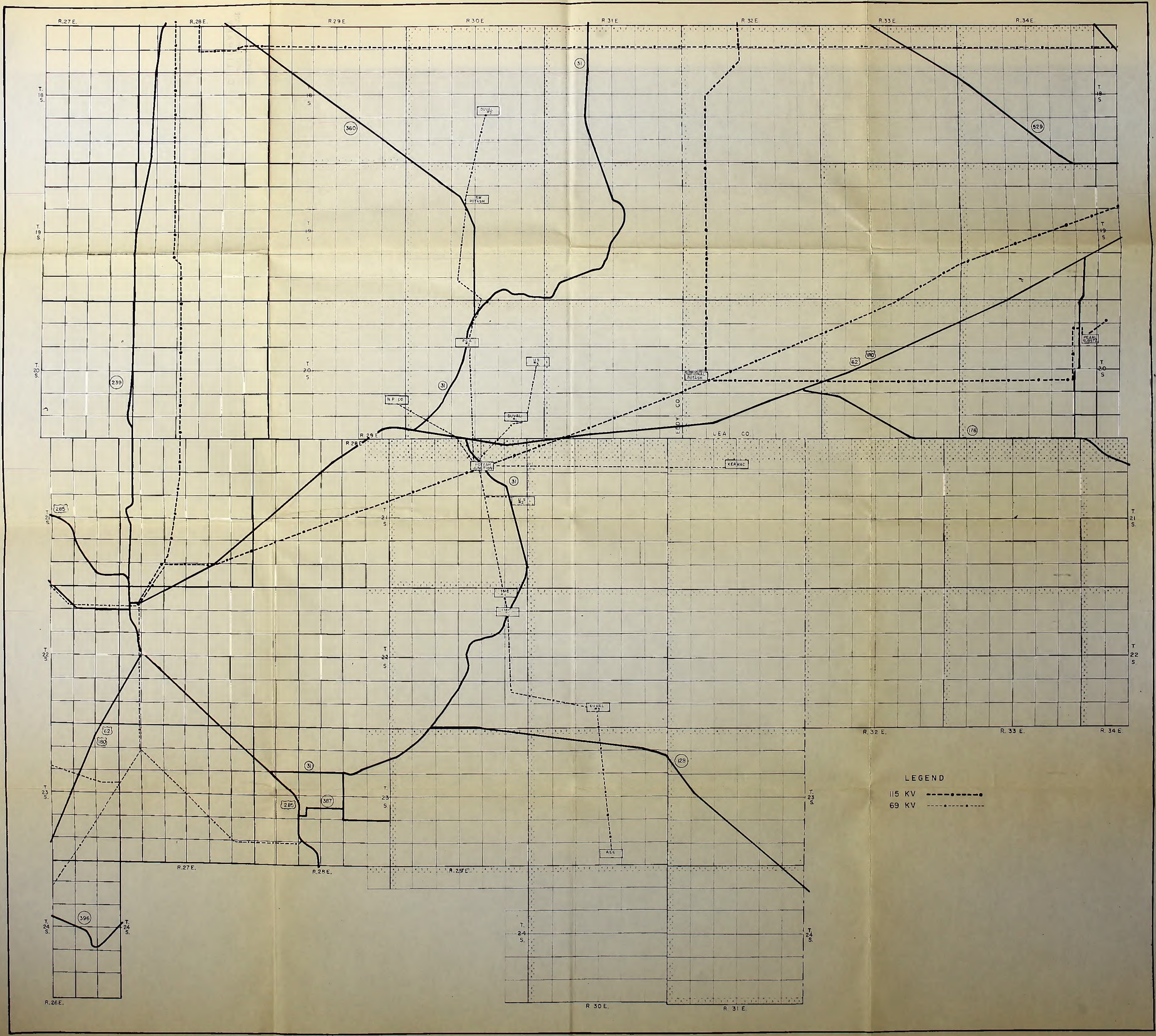

R.29 E.
R.30 E.
R.31 E.
R.32 E.
R.33 E.
R.34 E.
T. 18 S.
T. 19 S.
T. 20 S.
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R.28 E.
EDDY CO.
LEA CO.
CARLSBAD MINING DISTRICT
Area of mine workings
Area of economic potash resources
Area of subeconomic potash resources
2 1 0 2 4 MILES
1 0 1 2 3 4 5 KILOMETERS

Map II-5 General Subsidence
Map



Generalized map of the Carlsbad mining district showing areas where subsidence effects have likely occurred (shaded) and areas where effects can be expected to occur in the future (hachured)

Map II-24 Electricity Map


R.27 E.
R.28 E.
R.29 E.
R.30 E.
R.31 E.
R.32 E.
R.33 E.
R.34 E.
T. 18 S.
T. 19 S.
T. 20 S.
T. 21 S.
T. 22 S.
T. 23 S.
T. 24 S.
R.26 E.
R 30 E.
R 31 E.
R. 32 E.
R. 33 E.
R. 34 E.
360
31
529
239
62
180
176
285
128
387
396
DUVAL #2
SW POTASH
PCA #2
U S #3
NATIONAL POTASH
N P CO
DUVAL #1
PEARL SUBSTA.
POTASH JUNCTION
KERMAC
U S #2
IMC
IMC
DUVAL #3
AEC
EDDY CO
LEA CO
LEGEND
115 KV
69 KV

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Potash leasing in
southeastern New

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